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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*On the Products of the Explosion of Acetylene*; by W. G. MIXTER.

[Contributions from the Sheffield Laboratory of Yale University.]

THE study of the explosion of acetylene has been continued in order to obtain facts for or against the hypothesis advanced by the writer,* that a sufficient frequency of molecular impacts is requisite to secure spread of explosive change throughout a gas. For this purpose experiments were made with acetylene at high temperatures in tubes such as shown in fig. 1, in which the part *c* is about 20^{cm} long and 11 to 15^{mm} internal diameter. The tubes were filled at common temperature and atmospheric pressure by displacing the air with a current of dry acetylene, mercury serving as a trap in the bends *a* and *b*. Before sealing, the acetylene was blown out of the open ends, as the carbon separating from the gas when heated interferes with closing the tube. The mercury in *b* was shaken into *a* and the apparatus was hung in a Victor Meyer furnace so as to heat all of it below *a*. A standard thermometer was also hung in the furnace with its bulb near the middle of *c*. The reading of the thermometer was not corrected for the thread of mercury out of the furnace, as it accorded fairly with the temperature given by an air thermometer. The temperatures stated are very likely subject to a constant error of several degrees, but the differences in temperature are sufficiently accurate for the work. When the temperature was constant for some minutes strong sparks were passed for an instant between

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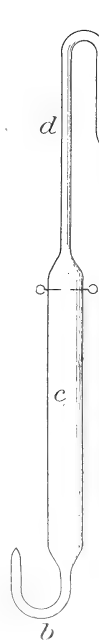


* This Journal, vii, 323, 1899.

the electrodes. The flash at the time of the puff or explosion was reflected from the upper part of *d* and the increased pressure was indicated by the change in the position of the mercury in *a*. In no instance was the explosion violent, nor did the decomposition of the acetylene extend into the narrow tubes. The hydrogen remaining after absorbing acetylene with ammoniacal cuprous chloride was the measure of the acetylene decomposed. The difference between the volume of acetylene taken and the volume of the gas after explosion was considered as the measure of the acetylene which had been converted into condensation products. The results are given in parts of 100 volumes of the gas taken.

No. of Exp.	Diameter of tube.	Temperature before sparking.	Acetylene decomposed.	Acetylene condensed.	Acetylene in residual gas.
1	12mm	325°	7		
2	"	325°	8		
3	"	330°	25		
4	"	335°	30		
5	13mm	340°	50		
6	12mm	345°	56		
7	"	345°	50		
8	"	356°	80		
9	11mm	365°	50		
10	"	above 365°	50	20	30
11	15mm	350°	70	6	24
12	"	above 400°?	50	10	40
13	"	347°	61	17	22
14	"	447°	50	20	30
15	"	478°	10?	40	50

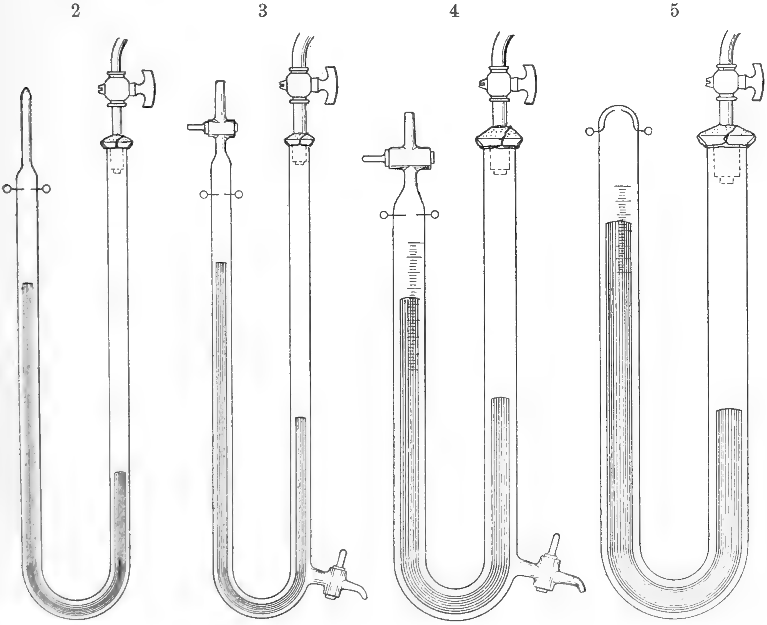
At the highest temperatures given in the above table acetylene forms condensation products, but too slowly to interfere with the results. When the gas was heated for an hour and a half to the highest temperature attainable by the furnace, probably about 500°, a black coating formed on the platinum wires in the tube and a starry deposit on the glass, and the gas remaining was two-thirds the original volume. The temperatures in the last three tests were obtained with an air thermometer.* In Experiment 15 there was no explosion; perhaps the

* The air thermometer was made about the same capacity and out of the same piece of glass tubing as the apparatus holding the acetylene. Its capacity in grams of water was found and then it was filled with dry air, fastened to the acetylene tube and both tubes were hung in the furnace. Just before sparks were passed through the acetylene the air thermometer was sealed. When cold it was opened under water of known temperature, closed again, wiped dry and weighed. The data for finding the temperature were the volume and temperature of the air in the tube before and after heating. The temperature of 347° obtained in 13 accorded fairly well with that given by the mercurial thermometer hung in the furnace with the air thermometer.

spark did not pass in the gas. It is probable, however, that sparking caused a change consisting chiefly of polymerization. The appearance of the tubes after explosion suggested that falling and glowing carbon effected part of the change. In order to get evidence of this and also to observe the glow, experiments were made in a tube with stop-cocks at its ends having a diameter of 15^{mm} and a capacity of 80^{cc}. I am indebted to Dr. Boltwood for his kindness and skill in making this tube. It was filled with dry acetylene at a pressure of about 2·3 atmospheres, and was placed upright with the electrodes at the lower end. Experiments 16, 17 and 18 gave 9, 14 and 10 per cent respectively of acetylene in the gas remaining after the explosion. In each case a glow filling 3 or 4^{cm} in length of the tube passed slowly to the top.

Since acetylene was found in the gas after explosion in all of the foregoing experiments, it seemed best to make more tests of the gas when under pressure. For this purpose the next series of experiments were made in the U-tubes shown in figs. 2, 3, 4 and 5.

2 3 4 5



No. 2 had an internal diameter of 10^{mm} and was filled with about 15^{cc} of dry acetylene; 3 a diameter of 11^{mm} and 30^{cc} of gas; 4 was a graduated eudiometer 17^{mm} in diameter and was filled with 60 to 80^{cc} of gas. No. 5 was also graduated and was

20^{mm} in diameter. It differed from the others in having the ends of the electrodes almost touching the upper inner surface of the glass. The experiments were made at the temperature of the room. The results are in volumes per hundred of gas taken.

No. of Exp.	Diam. U-tube.	Pressure.	Acetylene decomposed.	Acetylene condensed.	Acetylene in residual gas.
19	17^{mm}	2·6 atmos.	47·2	6·2	46·6
20	10^{mm}	3· "	50·	10·	40·
21	10^{mm}	3· "	79·	5·	16·
22	11^{mm}	3· "	74·	13·	13·
23	17^{mm}	3· "		5·8	
24	11^{mm}	3· "	60·	10·	30·
25	17^{mm}	3· "	40·	5·	55·
26	10^{mm}	3· "			6.25
27	20^{mm}	3· "	76·2	19·	4·8
28	20^{mm}	3· "	74·3	19·2	6·5

In 19, 21, 22 and 23 the explosion was prompt and violent, while in 24 and 25 it was slow. The character of the explosion in No. 20 was not noted. The volume of the exploding gas in No. 23 increased three-fold. Fearing an accident, I unfortunately did not view Nos. 27 and 28, in which the decomposition was not of an explosive character, for in 27 the volume of the gas was increased only 1/5 by the heat. Moreover, in these cases there was no dull thump, as there was when the gas was exploded in the other eudiometers. In both 27 and 28, where the gas was subjected to sparks at the surface of the glass in the upper end of the eudiometer, the carbon was deposited on the sides of the tube in brilliant black rings shading into dull black, showing that there was a peculiar wave motion in the decomposition. These rings were about 2^{cm} from center to center, or about the diameter of the tube.

It has commonly been considered that acetylene, when exploded, separates completely into carbon and hydrogen. Berthellot and Vieille* state in substance that when exploded under pressure it is decomposed into carbon and hydrogen gas having the volume of the acetylene taken, and Berthellot and Chatelier,† in their paper on the velocity of explosion of acetylene, discuss the phenomenon on the assumption that the products of the explosion are solid carbon and gaseous hydrogen. Doubtless these constituted most of the product at the high pressures, 5 to 30 atmospheres, they used. My experiments thus far given show conclusively that acetylene is not completely decomposed when exploded at 3 atmospheres in glass tubes 20^{mm} in diameter or narrower. Experiments were next conducted in a

* Comptes Rendus, cxxiii, 523. † Comptes Rendus, cxxix, 427.

rough bomb made of steam fittings. About 6 per cent of acetylene was found in the gas remaining after an explosion under a pressure of 3 atmospheres. The apparatus was unsatisfactory, as it had three small metal tubes in which perhaps the acetylene was under the same conditions as it was in the glass eudiometers. To avoid these objections, another bomb, fig. 6, was made from two cylinders such as are used to hold liquid nitrous oxide. It is essentially an iron cylinder $7{\cdot}5^{cm}$ in diameter, having a capacity of one liter. All of the metallic surface of

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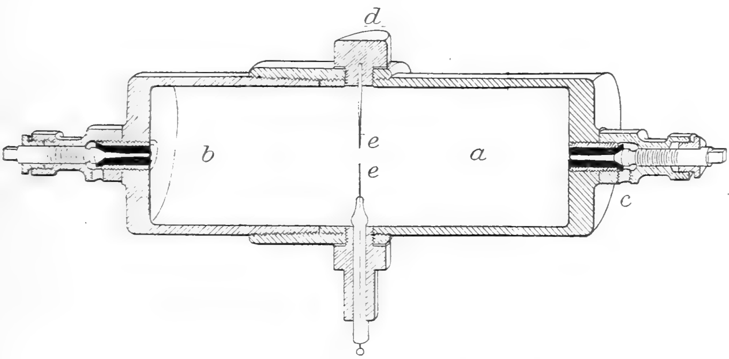

the inside was smooth and bright. The part *a* was fastened permanently in the coupling and the part *b* was connected by a screw made gas-tight with wax which did not reach the inner ends of *a* and *b*. These ends fitted closely. The electrodes *ee* were in the middle of the bomb, one was insulated and the other was connected with the metal of the bomb. It was filled by means of a pump with acetylene from a gas holder. The gas was dried by passing it through a cylinder filled with a kilo of small stick potash. After the air had been displaced the manometer was connected at *c* and the gas was slowly pumped in until the pressure was in excess of that desired. Then 100^{cc} of the gas from the bomb were passed into a eudiometer and treated with ammoniacal cuprous chloride to determine its purity. The manometer was disconnected before exploding, since it was shattered by the first explosion in the smaller bomb. The explosion was effected by sparks from a coil giving a 4^{cm} spark in air. To ensure brief sparking the primary circuit was closed for an instant only. The explosion was noiseless, but the result was evident from the increased temperature of the bomb.

Experiment 29.—Gas, 99 per cent of acetylene; pressure, 3 atmospheres. Two determinations of acetylene gave 4 and 4·1 per cent. The carbon was quite bulky, filling about half of

the bomb, and adhering rather firmly to the metal. A faint odor of hydrocyanic acid was perceived on opening the bomb, but no satisfactory reaction was obtained for it. The wooden insulator was slightly browned. It is not probable that any acetylene was formed from the wood, as it yields, when heated, chiefly hydrogen and methane.

Experiment 30.—Gas, 96 per cent of acetylene; pressure, 3 atmospheres; 4·1 per cent of acetylene was found in the gas after the explosion. The odor of hydrocyanic acid was strong. The residual gas was passed through a solution of potassium hydroxide free from cyanide. To a portion of the solution ferrous-ferric sulphate was added, and the mixture was warmed and then cooled. On adding to it an excess of hydrochloric acid an abundant precipitate of Prussian blue formed. If the gas contained cyanogen, this would have formed with potassium hydroxide, cyanide and cyanate. The latter is converted into an ammonium salt on adding an acid. A test did not yield any ammonia, but the negative result is not in this one test to be regarded as proof of the absence of cyanogen.

In the explosions in the U-tubes the gas expanded, often to twice or thrice the original volume, thus allowing the products of the explosion to cool more rapidly than when the volume is not changed at the instant of the explosion. In order to imitate to some extent the conditions in the explosions in the U-tubes, the plug of the bomb was replaced by the check valve, fig. 7. This was designed to close the opening after the gas ceased to escape and thus prevent air from entering the bomb. It was also sealed promptly with wax. A small platinum wire for an electrode was fastened in the opening *a* with a bit of pyroxylene and a few milligrams of beeswax was melted into it. The 4^{mm} hole in the last experiment was too large to close in this way, hence it was plugged with a bit of glass tubing holding the electrode. No wax was exposed to the gases in the bomb. The glass broke promptly when the explosion occurred. In Experiments 31 and 32 an insulator made of glazed clay pipe stem was used. It was cracked by two explosions so that it ceased to insulate. In the remaining experiments glass insulators made of heavy barometer tubing were used. The portion of the glass in the bomb was cracked as if dipped when hot into water.

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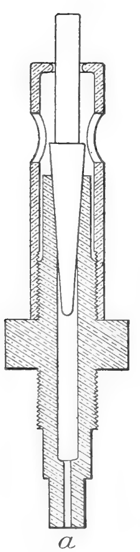


a

Experiment 31.—Gas, 99 per cent of acetylene; pressure, 3 atmospheres; hole, $1{\cdot}1^{mm}$ in diameter. Gas and carbon escaped

for perhaps three to five seconds and burned with a luminous but smokeless flame. Two estimations of acetylene in the residual gas gave respectively 5·2 and 5·4 per cent.

Experiments 32 and 33.—These were made as nearly as possible under the same conditions as 31. The residual gas in 32 yielded 6·6 and 7 per cent of acetylene, and that in 33 4 per cent of acetylene.

Experiment 34.—Gas, 98 per cent of acetylene; pressure 3 atmospheres; hole $2·1^{mm}$ in diameter. The residual gas yielded 5·7 and 5·5 per cent of acetylene.

Experiment 35.—Pressure 3 atmospheres; hole 4^{mm} in diameter. Each of two estimations of acetylene in residual gas gave 4·2 per cent.

Berthellot and Vieille* found in their experiments that the pressure in an explosion is about eleven times the initial pressure, corresponding fairly with the pressure of the gas at the calculated temperature of 2790° C. In the explosion in the bomb above described, the temperature was very high, as platinum wire was repeatedly melted and made brittle. But a wire in contact with the pipe-stem insulator was not melted. The shattering of the glass insulators was undoubtedly due to the intense heat, for in no instance was a glass eudiometer cracked, the quantity of heat not being sufficient to affect the glass. Berthellot and Chatalier† found the velocity of explosion in narrow tubes at pressures from 5 to 30 atmospheres to be 1000 to 1600 meters per second. In my experiments at 3 atmospheres in glass tubes the velocity was low in some cases.

The experiments 1 to 15 were made with an equal number of molecules in a unit of space. At 325° the decomposition did not extend throughout the gas, although here the energy of the system was greater than that containing twice as many molecules at 0° in the same space—a condition in which decomposition will propagate itself. In the cool and denser gas the molecular impacts are more frequent than in the hot gas. At temperatures above 325° the decomposition was self propagating. Here we have impacts of sufficient frequency to cause explosion. It is highly probable that acetylene at 400° and atmospheric pressure will not explode. The results at high temperatures present the striking fact that the amount of acetylene decomposed, or rather the hydrogen remaining, is fairly constant in a range of 100°, that is, from 350° to 450°. The products at high temperatures and in the U-tube tests were essentially alike, consisting of carbon and hydrogen, condensation products and acetylene. The wave-like character observed in 27 and 28, suggests that the marked variation in the results ob-

* Loc. cit. † Loc. cit.

tained in U-tubes was due to differences in the way the sparks started the decomposition. The acetylene in the residual gas in the experiments in the tubes when the explosions were violent was either a portion that escaped decomposition because of the cooling at the sides of the tubes, or it was formed from carbon and hydrogen at high temperatures. The experiments with the bomb were more satisfactory as regards uniformity of results than those made in the smaller pieces of apparatus. The escape of gas at the time of an explosion in the bomb did not increase the amount of acetylene left. Perhaps the expansion was not sufficiently rapid. The presence of acetylene to the extent of 4 to 6 per cent in the gaseous product of explosions in the bomb must be regarded either as a part of the original gas which escaped decomposition, or it was acetylene formed synthetically. It hardly seems probable that any gas at the time of the explosion remained below the temperature requisite for decomposition when the mean temperature was far higher and at the surface of a glass insulator was sufficient to crack it; moreover, the carbon separated remains incandescent for a perceptible time and must effect decomposition. It would seem then that the acetylene in the residual gas is not part of the original gas but is formed from carbon and hydrogen after the explosion when the carbon is either in the gaseous state or exists in molecules containing but few atoms and capable of uniting with the hydrogen. This view is supported by the fact that acetylene is formed in the voltaic arc. The proof given of the formation of an endothermic compound of nitrogen and carbon, not originally in the apparatus, also affords a strong support to this view of the production of acetylene by synthesis.

It is the intention of the writer to continue the work with acetylene under different pressures than three atmospheres, and to make experiments with mixtures of acetylene and nitrogen.

ART. II.—*Notė on the Glaciation of Central Idaho;* by GEORGE H. STONE.

CENTRAL IDAHO is rugged and mountainous, a succession of dark green and blue forested ranges. The rocks are mostly granites, schists, and quartzites, which in different regions vary greatly in capacity to withstand weathering and erosion. The larger streams flow in deep, cañon-like valleys, which broaden into plains in places where the rocks are easily disintegrated. Several of the principal watersheds consist of rolling plateaus but little dissected by erosion. They appear to be remains of what was once a large plain-like plateau and have an elevation of 7,000 to 8,000 feet above the sea. Approaching the larger rivers, we find the slopes becoming steeper and the whole country deeply dissected and accentuated by erosion, until we reach the principal rivers, the Snake and the Salmon, flowing in valleys of erosion 6,000 or more feet in depth. A few ranges appear to have been raised above the adjacent parts and are mountains of upheaval. During glacial time the relief forms of the land were substantially the same as at present. All of the large ranges and many of the peaks now having an elevation of about 6,000 feet shows signs of extinct glaciers. The geographical position of Idaho with respect both to the Pacific Ocean and the vast Canadian areas of extreme winter cold, is favorable to a large snowfall, both now and at all times since the rise of the continent above the ocean. The following personal observations were made by the writer during a recent reconnoissance.

The mountain ranges that form the watersheds between the Boise, Payette, and Salmon rivers formed the gathering ground of numerous local glaciers. Those which flowed south and west down the valleys of the Boise and the Payette ended at not far from 5,000 feet elevation. Those flowing north and east down the valleys of the South and Middle Forks of the Salmon reached a somewhat lower elevation, but none of them reached so low an altitude as the main Salmon river, which in this part of its course has an elevation of less than 1,000 feet. From the east and west divide between the Salmon and the Clearwater, local glaciers flowed south into the gorge of the Salmon, but none appear to have reached that river. From this same divide glaciers flowed north to the South Fork of the Clearwater. The broad valleys of both the South and Middle Forks of the Clearwater were covered by valley glaciers, i. e., the local glaciers that originated in the Bitter Root range and the higher ranges that form the rims of these basins united to

form a confluent ice sheet in each valley. The ice covered all the lower hills in the central parts of each drainage basin and flowed westward up and over these hills, and finally narrowed into the deep cañons which form the channels of the South and Middle Forks at and below 3,500 feet elevation. The great ice sheet which at one time covered British Columbia east of the Cascade range, and which had a southward flow during the time of deepest ice, did not reach so far south as the Clearwater valley. The valley ice sheets of the South and Middle Forks of the Clearwater closely correspond to what Russell has termed the Piedmont type of glaciers.

The signs of glaciation in all the region in question are distinct and unmistakable. Morainal ridges and terraces are common in the higher valleys, but in general the ice appears to have retreated at so uniform a rate as to leave most of the morainal matter in the form of a diffused sheet. There are numerous lakes held in by morainal dams, as the Lower Payette Lake and Trout Lake on Lake Creek, a few miles southeast from Buffalo Hump. Only in few regions do the rocks withstand weathering so as to preserve the glacial scratches. At Buffalo Hump the granites, schists, and quartzites equal or surpass the best Maine and New Hampshire granite in capacity to withstand the elements, and the rock is beautifully smoothed and scored to within about thirty feet below the summit of the Hump. The glaciated stones are in general so smooth and rounded at the angles that they have often been mistaken for water-rolled stones, distinct scratches being rare. In the regions where the granite and schists weather readily, the morainal matter consists of smoothed stones of quartzite or other resistant rocks, scattered through angular sand and gravel resulting from the disintegration of the fragments of granite and schists. In many cases the glaciated stones are remarkably round and smooth almost to the tops of ridges from which the ice flowed in opposite directions, as on Buffalo Hump and on the much dissected ridge dividing Boise Basin from the valley of the South Fork of the Payette. Much, perhaps most of the morainal matter was sub-glacial, which accounts for the great attrition it received.

The water-transported deposits of the glaciers of this region were mostly "overwash," i. e., were sediments poured out of ice channels into open ground beyond the front of the ice. These are sometimes plain-like, as at Warren Meadows; at other times they take the form of terraces in the narrow valleys. The overwashed gravels have often been regarded as lake beds, especially when they expand into broad plains. Not seldom sediments were deposited in the beds of streams and lakes between the margin of the ice and adjacent hills. The Payette

formation of Lindgren's map of Boise Basin is, at Placerville at least, of glacial age and glacial origin.

A short distance south of Elk City is a series of glacial gravels deserving special study. A gravel plain one-eighth of a mile to about a fourth of a mile in breadth, and in places eighty feet deep, leaves the valley of Red Horse river, and extends seven miles westward, first going obliquely over hills more than 100 feet high; then for two miles is on the top of the hills immediately adjoining the American river on the south; then crosses that stream obliquely, ascends a hill; then crosses the valley of Elk Creek nearly at right angles and ascends another hill to Buffalo Hill placer. The American Hill placer is part of this gravel system. I did not follow the course of this interesting gravel system east or west of the points named, but it probably can be traced for miles in both directions. The direction of transportation was westward. Above the point where this gravel system crosses the American river, the gravel of that stream is much less worn and rounded than below that point. The materials of this gravel plain are very round and smoothed gravel, cobbles, bowlderets and even some bowlders, and they have afforded millions in gold. On the hills between Red Horse and American rivers the placer miners have washed away the overlying gravel. The rock beneath the gravel is very much smoothed and polished, but is very uneven, containing many rounded depressions, bowls and pot holes up to five feet in depth. Evidently here was a broad river that flowed up and over hills and valleys. That it disregarded the surface forms of the land proves that it was enclosed between walls of ice. The stratification is not arched in cross section like that of the osar proper, but is horizontal, like the deposit I have elsewhere described as the osar plains of Maine.

An interesting feature of this gravel system is the fact that it contains multitudes of fragments of cedar wood, mostly at certain horizons at considerable height above the bottom of the gravel. Some of these pieces retain their original state and will burn after being dried; others have been changed into an imperfect lignite, while the greater number have been partly or wholly silicified. The growth rings prove they were mostly derived from trees of considerable size. I saw no pieces of a whole trunk; all had been split and broken across into pieces of all sizes up to twelve inches in thickness and up to eight feet in length. All the pieces have been smoothed at the sides and well rounded at the ends and angles.

The facts prove that here was once a river of water flowing through a stagnant glacier that had become covered with a forest growth like many of the Alaskan glaciers to-day. No

matter whether the glacial river flowed in a sub-glacial, or englacial, or in a superficial channel during the time of rapid flow of the ice, it must have flowed in an open ice cañon during the period of stagnation. Into this cañon trees that were growing on the glacier fell as they were undermined by the melting of the ice walls of the channel. The fact that the trunks were broken into so small fragments indicates more force than is usual in the case of ordinary stream channels. Probably the motion of the ice helped to break up the trees, assisted by ice and timber dams or gorges.

The occurrence of wood in the esker gravels of Idaho suggests a comparison of that region with New England.

In New England there were many level regions, especially in Maine to the north of east-and-west ranges of hills, where the ice would naturally become stagnant during the final melting and retreat of the great ice sheet. The Idaho facts suggest that if vegetation crowded close on the front of the New England ice sheet, the stagnant ice ought there to become forested as in Idaho. In this case we ought to find pieces of wood in the broad osar plains of Maine and in such portions of the valley drift as were glacial overwash. No wood or other land organic remains have yet been found in these deposits in Maine, though Emerson has found in the Connecticut valley vegetable remains in sediments of glacial age. The absence of wood from the eskers and valley drift of all of northern and northeastern New England can fairly be urged as proving that forests did not press closely on the front of the retreating ice sheet in that region. This is supported by another consideration, viz., that at the time of maximum glaciation the ice confronted the sea along the whole New England coast. When the ice retreated, vegetation would have to advance a long way eastward as well as northward in order to reach Maine from New Jersey, the nearest land then covered by vegetation, unless possibly we except Nova Scotia. The above considerations make it probable that the stagnant marginal portions of the retreating New England ice sheet did not become forested, at least toward the northeast.

The large valley ice sheets or Piedmont glaciers of north-central Idaho formed a type intermediate in character between the more strictly local glaciers found farther south, and the great confluent ice sheet of British Columbia.

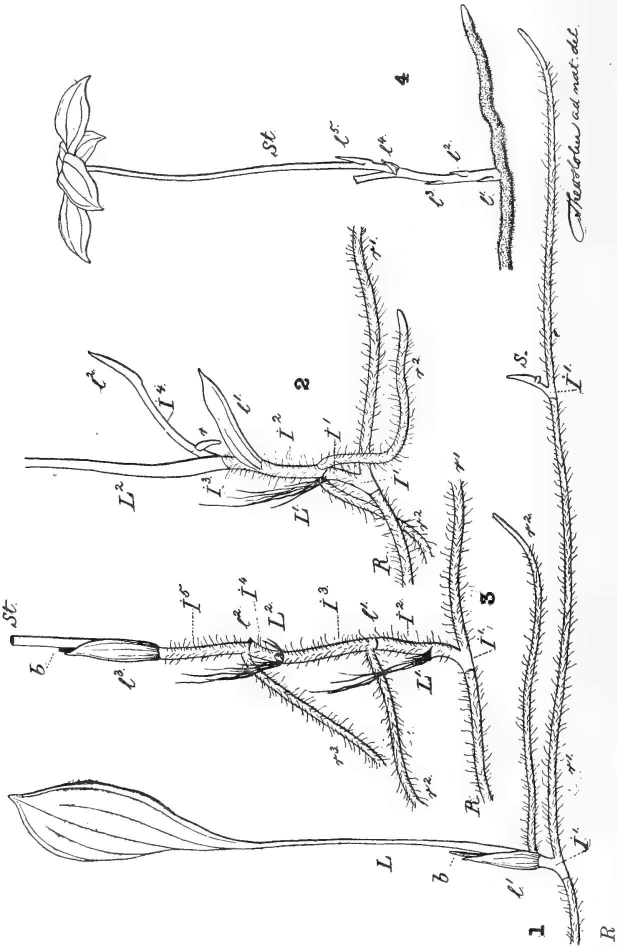
November, 1899.

ART. III.—*Pogonia ophioglossoides* Nutt. *A morphological and anatomical study;* by THEO. HOLM. (With four figures.)

THE genus *Pogonia* is represented in the Atlantic States by five species, which according to Bentham and Hooker are to be classified in no less than three sections, viz: *Eupogonia* (*P. ophioglossoides* Nutt. and *P. divaricata* R. Br.), *Triphora* (*P. pendula* Lindl.) and *Codonorchis* (*P. verticillata* Nutt. and *P. affinis* Aust.). It deserves notice that these sections are established rather upon the vegetative than upon the floral characters, and Bentham and Hooker have pointed out, that the stem has but one leaf, one bract and one flower in *Eupogonia*, while in *Triphora* there are several leaves, bracts and flowers; finally in *Codonorchis* the stem bears a whorl of three to six leaves and a single flower or seldom two as in *P. affinis*. Besides these vegetative characters the floral ones offer several important points useful to the classification of these singular plants, thus Nuttall and Rafinesque separated their genera *Triphora* (Nutt.), *Isotria* and *Odonectis* (Raf.) from *Pogonia* proper, the two last being, however, identical with *Codonorchis* Lindl. It must be admitted that the general habit of these plants is very different, and even if no further distinctions were to be drawn than those recorded by Bentham and Hooker, it would seem very natural to consider these species as representing three well defined genera. However if we examine the parts underground, we find a few additional characters, which are no less important to the classification of the species.

The roots are generally described as "thick fibers," "a cluster of fibers" or "oblong tubers" and Willdenow described his *Arethusa pendula* as possessing a tuberous root; this plant is Nuttall's *Triphora pendula*, and it is, also, the "Helleborine mariana, flore pendulo purpureo trianthophoros" of Plukenet. But otherwise the systematic authors give no further details in regard to the root-system and no information whatever concerning the rhizome. Our species of *Pogonia* are all terrestrial and, excepting *P. pendula*, possess a slender rhizome, which is relatively short, vertical or ascending and densely covered with long, unicellular hairs. Underground stems with hairs are rare, but are known in other genera of the *Orchideæ*, for instance *Listera*, *Goodyera* and the rootless *Corallorhiza*. In examining a rhizome of *Pogonia ophioglossoides* (fig. 3) we find it consists of five distinct internodes (i^1 - i^5), the uppermost (i^5) passing into a flower-bearing stem (St.). The rhizome is vertical, bearing rudiments of two green leaves (L^1-L^2) and two scale-like and membranaceous (l^1-l^2), while a third scale-like one is still fresh and surrounds the base of the flower-bearing

stem (l^3). Characteristic of the rhizome is the monopodial growth, which ceases, however, when the flower-bearing stem dies away. After that time it becomes a sympodium, as the axillary bud (*b*) will develop and continue the growth of the rhizome. This is, however, not the only bud, which is visible



at the present stage, since another one, though dormant, is developed in the axil of the leaf L^2. It is evident that this dormant bud would have grown out into a branch, if the upper part of the rhizome might have become injured, but not otherwise. The same mode of growth is, also, to be observed in such specimens, which are yet purely vegetative as the one drawn in fig. 2. In this the green leaf (L^2) and the scale-like

one (l^1) are still fresh and the apex of the rhizome is terminated by a bud, surrounded by the scale-like leaf l^2. There appears thus to be a regular succession of green and scale like leaves, but the most common case is, however, that the first leaf of the root-shoots is scale-like instead of being a green, assimilating one.

In passing to describe the root-system, it may be stated at once, that the main propagation of our plant, *P. ophioglossoides*, seems to take place by means of root-shoots. All the specimens which were collected by the writer in a Sphagnum-swamp near Washington, D. C., were developed from roots, and the same was, also, the case with a number of specimens from a similar locality in Maine, kindly furnished by Mr. M. L. Fernald of the Gray herbarium, Harvard University.

This is the more surprising since, so far, but very few of the *Orchideæ* are known to propagate in this manner, the only ones being: *Neottia Nidus avis* (L), *Cephalanthera rubra* (L), *Epipactis microphylla* (Ehrh.) and *Listera cordata* L., all from Europe; besides that we have, also, observed a similar development of root-shoots in *Pogonia verticillata* (fig. 4). It is very likely that similar cases may be observed in *P. divaricata* and *P. affinis*, but our dried material, the only one being at hand, was not preserved very carefully so as to demonstrate the root-system. It appears as if this formation of root-shoots is confined to such genera, in which no tuberous roots occur, and in which no tuberous or bulbous stem-internodes are developed. We might suppose that several of the other *Orchideæ* really exhibit the same manner of propagation, but only those of which the root-system is similar to that of *Pogonia* or *Neottia*; it is, no doubt, a character common to the species of *Listera*, *Cephalanthera*, *Epipactis*, and perhaps also to *Cypripedium*, at least in some of those roots which run in a horizontal direction close beneath the surface of the ground. Among the dicotyledonous orders many species propagate in this way, and we need only to refer to the long lists of such plants, contributed by Warming and Wittrock.* However, root-shoots may be of very different kind, and Professor Wittrock has proposed three categories in regard to the circumstances under which they may occur and in regard to their importance to the mother-plant: reparative, additional and necessary.† The root-shoots

* For references consult the bibliography appended to this article.

† Reparative root-shoots being such which develop only in cases where the root becomes broken away from the mother-plant, and the mother-shoot thus becomes injured or killed: *Taraxacum*, *Centaurea Scabiosa* and *Bunias orientale* for instance. Additional root-shoots develop, on the contrary, spontaneously upon roots of uninjured specimens hence forming a more or less important addition to the reproduction of the individual: the majority of plants with root-shoots Necessary are such as constitute a part of the normal, morphological development of certain plants, e. g. *Pyrola uniflora*, *Monotropa Hypopitys*, *Cirsium arvense*, etc.

of our *Pogonia* belongs to the second of these categories, as they merely serve as additional means of the vegetative propagation of this plant. The development of these shoots in *P. ophioglossoides* is interesting and agrees in all respects with the observations made by Brundin in *Listera cordata* L. The most characteristic is that the shoot develops as terminal at the end of a root, and that a secondary root pushes out from the base of the young shoot and in the same direction as the mother-root, as if it was a continuation of this. It is, moreover, to be noticed that this secondary root repeats the development of another shoot in exactly the same manner as the first. This is readily to be seen in fig. 1, where a small shoot is developed at S, of which the first secondary root continues the direction of the older and bends upwards, terminated by a similar growing-point, in which the character of root suddenly becomes changed to that of a stem. That these root-shoots are not lateral, as it might seem from the first glance, but terminal is furthermore explained by the very distinct cross-line, shown on our figure, where the root-hairs cease and from where a stem-part (i^1) arises, while the first secondary root (r^1) develops from this basal stem-part and grows out horizontally in the same direction exactly as the old root (R). The study of the growing-point itself shows this development still more plainly. The roots of *P. ophioglossoides* are very slender, and those we have described above run immediately in a horizontal direction; most of the other secondary roots, on the contrary, which develop higher up on the shoot (r^2–r^3), in figs. 2 and 3, grow often from the beginning downwards, almost vertically, but change their course gradually into the horizontal direction. None of these roots were observed to develop shoots, and their function is perhaps to absorb nutritive matters, and to support the aërial shoot. The very long, horizontal roots, afford an excellent method of distributing the new individuals to a considerable distance from each other. In regard to *P. verticillata* (fig. 4) the roots develop similar shoots, but these do not appear to be terminal, but lateral; our material, however, was too scant to allow any decisive opinion in this respect.

In comparing the rhizome itself of *P. ophioglossoides* with that of *P. divaricata*, the only variation to be observed is that the internodes of the rhizome in the latter are relatively much shorter, while the roots show a like external structure. A similar very short, but strictly vertical root-stock is, also, to be found in *P. verticillata*, which, however, differs from all the others, only excepting *P. affinis*, in having the aërial leaves arranged in a whorl, besides the very striking difference in the floral structure. In the last species of *Pogonia*, *P. pendula*, we notice a rhizome of very singular structure. This species

possesses a tuberous, underground stem, of which, however, only one internode seems to be swollen, from the apex of which the aërial stem arises. The tuber is oblong, covered with short hairs, and bears only one small, scale-like leaf near the apex, from the axil of which a slender stolon develops and grows out horizontally. In the dried material of this plant, kindly furnished to the writer by Mr. Thomas H. Kearney, the stolon was unfortunately not completely preserved, the apex being broken off. We suppose, however, that the tuber develops at the end of the stolon in the same manner as we have observed in *Medeola*, but the tuber of this plant is composed of several thickened internodes instead of but one as in *P. pendula.* The other parts of the rhizome, the basal internodes of the stem, are vertical, slightly hairy like the stolon and provided with a few secondary roots, slender and very hairy. No root-shoots were found in this species, and we did not expect to find such, since the plant is stoloniferous. As stated by Professor Wittrock (l. c.) no stoloniferous plant has, so far, been observed to develop root-shoots. It seems now from these observations as if *P. ophioglossoides* and *P. divaricata* are closely related species, that they exhibit morphological characters that are very different from those of *P. verticillata* and *P. affinis* on the one side and from *P. pendula* on the other.

While studying the anatomical structure we noticed a few points which may be of some interest for further studies of North American *Orchideæ.* The roots in these species are Mycorrhizæ, and the fungal hyphæ were observed in the epidermis, the hypoderm and in the outer strata of the bark-parenchyma. The endodermis is thin-walled, but in *P. verticillata* there is constantly one, or very seldom even two, quite thick-walled endodermis-cells just outside the leptome. The pericambium is thin-walled and in no instance interrupted by the proto-hadrome vessels ; furthermore, the conjunctive tissue is quite thick-walled in *P. verticillata*, but not so in *P. ophioglossoides* and *P. pendula.* The rhizome contains fungal hyphæ, which are located in the epidermis and outer bark, and the epidermis has developed numerous long, unicellular hairs of a structure like those of the roots. No stereome is represented in the rhizome, and a thin-walled endodermis surrounds a circle of mestome-bundles, which are bicollateral, perihadromatic, in *P. verticillata;* there is, furthermore, a central pith of thin-walled cells in *P. pendula* and *P. ophioglossoides*, but of thick-walled in *P. verticillata.* The tuber of *P. pendula* has a huge bark and pith, and the very small mestome-bundles are arranged in a circle inside a very thin-walled endodermis ; the epidermis of the tuber contained hyphæ. The aërial stem of *P. ophioglossoides* and *P. verticillata* is hollow and pos-

sesses a ring of stereome around the mestome-bundles, all of which are collateral and very regularly arranged in a circle. A thin-walled, broken pith occupies the inner part of the central-cylinder.

In considering the leaves, these are vertical in *P. ophioglossoides*, but are kept in a horizontal position in *P. verticillata;* they are, nevertheless, almost isolateral in both species, the mesophyll being of a homogeneous structure throughout the blade; however, the epidermis shows on the upper face in both species to consist of much larger cells than on the lower; moreover, the radial cell-walls of epidermis are straight on the upper, but undulate on the lower surface in *P. ophioglossoides*, while they are undulate on both faces in the other species. The stomata are restricted to the lower surface, and the guard-cells are very prominent in *P. ophioglossoides*, but not so in the other. The mestome-bundles are surrounded by a partly green parenchyma-sheath, and only in *P. ophioglossoides* are supported by a small, thin-walled stereome.

In bringing these facts together there appears to exist even anatomical characters, by which *P. verticillata*, *P. ophioglossoides* and *P. pendula* may be distinguished from each other. And although it was the main object of this article simply to call attention to the presence of root-shoots in *Pogonia*, we naturally felt obliged to examine the systematic position of these species, by which we noticed that not all our *Pogoniæ* are Pogonias in the stricter sense of the word. It would seem more natural indeed to adopt the classification proposed by Bentham and Hooker, to separate *Triphora* and *Codonorchis* from *Pogonia* proper.

Brookland, D. C., October, 1899.

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EXPLANATION OF FIGURES.

FIGURE 1.—*Pogonia ophioglossoides.* Rhizome showing a root-shoot developed from the root R, and a much younger one (S) developed from the root r^1; i^1 = the first internode of the root-shoot; l' = the first scale-like leaf; L = the green leaf; b = the terminal bud of the root-shoot. Natural size.

FIGURE 2.—Same species. A similar vegetative, but older root-shoot; r^1 = the first secondary root of the shoot; r^2 and r^2 = a pair of secondary roots developed from base of second internode; r = the secondary root from fourth internode; i^1-i^4 = the four internodes of the shoot; L^1 = scar with fibers left from the first green leaf; L^2 = petiole of second green leaf; l^1 and l^2 = scale-like leaves. This shoot is developed from apex of root R. Magnified.

FIGURE 3.—Same species. Flower-bearing root-shoot. St. = base of flowering stem; the other letters as above. Magnified.

FIGURE 4.—*Pogonia verticillata.* Vegetative shoot in its second year, developed on a root. St. = the stem, which at its apex bears a whorl of four green leaves. Natural size.

Art. IV.—*On Graftonite, a new Mineral from Grafton, New Hampshire, and its Intergrowth with Triphylite;* by S. L. Penfield.

Material for this investigation was sent to the author for identification by Mr. George L. English of New York, who, on being informed that it was probably a new mineral, took special pains to secure a supply of it, and has given the following information concerning its occurrence: The mineral was found on the south side of Melvin Mountain, about five miles west of the village of Grafton. It was irregularly disseminated through a coarse crystalline mass of quartz and feldspar, probably a pegmatite vein, the feldspar individuals being at times fully four feet long. Associated with the new mineral in the vein were found beryl, black tourmaline, almandine garnet, muscovite and biotite, all crystallized on a rather large scale, especially the beryl. All of the new mineral that could be found was taken from the vein, and the total output consisted of a few crystals and a considerable quantity of irregular fragments. The crystals and also the fragments present a rough, weathered appearance, and, what is unusual and at once very striking, they consist of alternating layers or lamellæ of dark and light material, the lamellæ being less than $0{\cdot}5^{mm}$ in diameter and often exceedingly thin. Both the light and the dark material gave reactions for a phosphate containing iron and manganese as bases. The light material, however, contained only ferrous iron, while the dark reacted chiefly for ferric. The light and dark portions were so nearly alike in specific gravity that they could not be satisfactorily separated by means of the silver-thallium nitrate fusion. The dark portion was found to have a somewhat lower specific gravity than the light, and a product was separated which represented a partial separation of the two minerals and consisted chiefly of the light-colored material. This was analyzed by Mr. W. E. Ford of the Sheffield Laboratory with results which are given beyond. The iron was found by Ford to be both ferrous and ferric, and, since a little of the carefully selected light-colored material gave only the reactions for ferrous iron, it was inferred that the original mineral was undoubtedly a ferrous compound, and that the dark portions were the result of partial decomposition, attended by the oxidation of the iron and manganese. Although the analysis indicated that the mineral was undoubtedly new, the results, owing to the character of the material, were not wholly satisfactory and conclusive, and there was some doubt as to the propriety of giving a new name to the species.

Fortunately for the solution of the problem in hand, among several pounds of material sent by Mr. English, a single fragment, about as large as the end of one's finger, was found, which showed only a very little of the dark, decomposed material. It was undoubtedly the central portion or core of a crystal, the outer portion of which had been oxidized, leaving within a core of fresh unaltered material. Upon careful examination this fresh portion was found to consist of two minerals in alternating layers, and fig. 1, which represents the appearance of a thin section prepared at approximately right angles to the lamination, will give an idea of the arrangement and relative proportions of the two minerals. The white portions, *g*, represent the new mineral, graftonite, which constitutes about two-thirds to three-quarters of the total material. This in the fragment possessed a delicate salmon color, but appeared almost colorless in thin section. The other mineral *t*, which in the figure is represented by the stippled portions, was found to be triphylite. The latter possessed a pale green color as seen in the fragment, but appeared almost colorless in thin section. The exterior of this fragment of fresh material showed in places a darkening, due to the oxidation of the iron and manganese, and the thin section showed, as represented by fig. 1, that the oxidation is confined wholly to the triphylite lamellæ, the new mineral being evidently a more stable material. On breaking up the fragment it was found that the lamellæ separated quite readily, and it was possible to obtain the two minerals practically pure, by careful working, splitting off lamellæ at times almost as thin as a sheet of paper, and examining each particle with a lens. Thus, discarding everything which seemed at all questionable and using all of the available material, 0·546 grams of the new mineral and 0·166 grams of the triphylite were secured. The specific gravity of the graftonite was found to be 3·672. The hardness is 5 and the luster is vitreous to resinous. In appearance it resembles very closely the salmon-colored varieties of lithiophilite. The associated triphylite was found to have a specific gravity of 3·58.

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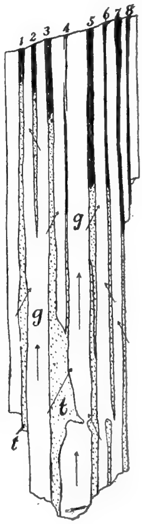

Making complete analyses of the two minerals on the small quantities of available material proved to be a somewhat interesting problem in analytical chemistry, and a brief outline of the method employed is as follows: It was first proved by qualitative tests that the iron was wholly ferrous. All of the

material of each substance being employed, water was first estimated by ignition in a closed tube, as described by the author.* The contents of the tube were then dissolved in hydrochloric acid, the solution evaporated to dryness and the residue was taken up in water and a very little acid. To this solution, heated to boiling, barium hydroxide was added, which precipitated barium phosphate, along with the iron, manganese, magnesium and the bulk of the calcium, leaving the alkalies in solution. After filtering, the barium was separated from the filtrate by means of ammonia and ammonium carbonate, and the alkalies were finally obtained in the form of chlorides. From the very hygroscopic character of the chlorides it was evident that lithium was the prevailing alkali, and, since the quantities were small, it was considered best to weigh the alkalies as sulphates, and subsequently determine the SO_3, thus obtaining data for estimating both the per cent of the alkali oxides, R_2O, and their joint molecular weight. The precipitate produced by barium hydroxide, containing the phosphoric acid and bases, was dissolved in hydrochloric acid, and barium was precipitated by means of sulphuric acid. The barium precipitates, obtained at this stage of the analysis and from the alkali separations, were carefully examined for traces of P_2O_5 and bases. The filtrate from the barium sulphate, containing P_2O_5 and bases, after evaporating to dryness and taking up in a very little acid, was diluted, heated to boiling, precipitated by an excess of sodium carbonate and filtered. The filtrate contained the bulk of the P_2O_5, which was precipitated by magnesia mixture. The precipitate consisted of basic phosphates and carbonates of iron, manganese, magnesium and calcium. The latter was dissolved in a little hydrochloric acid, and the iron in combination with the P_2O_5 was separated by a basic acetate precipitation. After filtering, the precipitate was dissolved in acid, the iron together with the P_2O_5 was precipitated with ammonia, weighed and subsequently the P_2O_5 was separated by means of ammonium molybdate. In the filtrate from the basic acetate precipitate the manganese, magnesium and calcium were estimated by well known methods.

The results of the analyses are given below, together with the analysis made by Mr. Ford on partially purified material.

The analysis of the triphylite, though showing a slight deficiency, compares favorably with the analyses of triphylite from Bodenmais, Bavaria and Norwich, Mass., made by the author† and quoted in Dana's Mineralogy, page 757. The alkali oxide was found to have a molecular weight of almost exactly 30, which is the molecular weight of Li_2O, thus indicating the purity of the oxide.

* This Journal, III, xlviii, p. 31, 1894. † Ibid., III, xvii, p. 226, 1879.

Quantity,	Triphylite. 0·1668 gr.	Graftonite. 0·5462 gr.	Ratio.	
P_2O_5	42·3	41·20		·290
FeO	33·4	30·65	·426	·857
MnO	9·9	17·62	·248	
MgO	1·3	0·40	·010	
CaO	0·2	9·23	·165	
Li_2O	9·2	0·33*	·008	
H_2O	1·7	0·75		
	98·0	100·18		

	Analysis by Ford.
P_2O_5	40·80
Fe_2O_3	10·16
FeO	24·28
MnO	15·38
CaO	7·25
Na_2O	1·15
K_2O	·14
H_2O	1·17
	100·33

As shown by the analysis of the graftonite, alkalies are practically wanting in the new mineral. The 0·33 per cent recorded as Li_2O was found to have a molecular weight of 44, indicating that the alkali was chiefly lithia, and it is probable that it was derived, for the most part at least, from a slight admixture of triphylite. Since triphylite, however, is a normal phosphate, its presence in very small quantity would have no appreciable effect upon the ratio of P_2O_5 to the total metallic oxides, and hence an amount of triphylite corresponding to 0·33 per cent of alkali oxide has not been deducted from the analysis. The ratio of P_2O_5 : RO, as indicated by the analysis, is ·290 : ·857 = 1 : 2·95, or, approximately, 1 : 3. The formula of graftonite is, therefore, $R_3P_2O_8$, R standing for the bivalent metals, iron, manganese and calcium, which evidently are isomorphous with one another and not present in fixed or definite proportions. In Ford's analysis the considerable amount of Fe_2O_3, which is recorded, indicates that the original mineral has suffered some alteration, attended by oxidation, the amount of oxygen in the 10·16 per cent of Fe_2O_3 in excess of FeO being 1·02 per cent. This oxidation, in all probability, belongs as much to the manganese as to the iron, if not more. If the oxidation is neglected, and the iron considered wholly as FeO, the ratio of P_2O_5 : RO in Ford's analysis becomes 1 : 2·90, or, practically, 1 : 3, as required by a normal phosphate. Moreover, the oxidation has not been attended by any considerable amount of hydration, the amount of water, 1·17 per cent, being small.

From a chemical standpoint graftonite is interesting as being one of the very few anhydrous, normal phosphates thus far observed. Thus, we have xenotime and monazite, normal phosphates of the yttrium and cerium metals, and the minerals of the triphylite group, characterized by containing an alkali metal, as follows: triphylite, $LiFePO_4$; lithiophilite, $LiMnPO_4$; natrophilite, $NaMnPO_4$ and beryllonite, $NaBePO_4$,

* Molecular weight 44, hence containing some Na_2O.

while all other mineral phosphates contain either fluorine or hydroxyl radicals, or water of crystallization.

Before the blowpipe graftonite darkens and fuses at about 2 to a globule which is slightly magnetic. The globule becomes decidedly magnetic after continued heating on charcoal. During fusion in the forceps the mineral imparts to the flame the pale bluish-green color characteristic of a phosphate. Fused in a sodium carbonate bead in the oxidizing flame, the green color characteristic of manganese is obtained. The mineral is readily soluble in hydrochloric acid, and if a little of the concentrated solution on a watch glass is brought in contact with a drop of dilute sulphuric acid a precipitate of calcium sulphate is formed. In the closed tube only a trace of water is given off, and at a full red heat the material shows signs of fusion.

The crystallization of graftonite is monoclinic, although no material for obtaining exact and reliable data has thus far been found. The crystals are without exception dark from the presence of oxidized triphylite, while the outer surfaces of the graftonite itself have undoubtedly suffered more or less oxidation. In some cases oxidation and decomposition have gone on to such an extent that only a rude suggestion of the crystal form remains. The crystals, moreover, are either fragmentary, or they are attached so that only a portion of their faces are developed. The crystals averaged over 4^{cm} in greatest diameter, and admitted only of approximate measurement by means of the contact goniometer.

The forms observed, which are represented in the accompanying figures, are as follows:

a, 100	*m*, 110	*n*, 130	*e*, 021
b, 010	*l*, 120	*d*, 011	*p*, 111

In establishing the axial ratio the value of β was derived from a direct measurement of the angle made by the edge between *b* and *e*, fig. 2, with the vertical edge between *b* and *n*. Other fundamental measurements were, $b \wedge m, = 51°$ and $b \wedge d = 62°$. The axial ratio obtained from these values is as follows:

$$a : b : c = 0{\cdot}886 : 1 : 0{\cdot}582\ ;\ \beta = 66°$$

It must be borne in mind, however, that the fundamental measurements are not very reliable, and that the axial ratio therefore can only be approximately correct.

A few of the more important measured and calculated angles are as follows:

		Measured.	Calculated.
$m \wedge m$,	$110 \wedge 1\bar{1}0$ =	------	78° 00′
$l \wedge l$,	$120 \wedge 1\bar{2}0$ =	115°	116 36, fig. 6
$b \wedge n$,	$0\bar{1}0 \wedge \bar{1}\bar{3}0$ =	22 30′	22 22, fig. 2
$e \wedge e$,	$021 \wedge 0\bar{2}1$ =	------	93 31
$p \wedge p$,	$111 \wedge 1\bar{1}1$ =	------	41 32

Figures 2 to 7 represent the crystals which were available for study. Fig. 2, drawn with b, $0\bar{1}0$, in front, shows a portion of a crystal, about 5[cm] wide, which is attached to a rather large, irregular mass of graftonite associated with biotite. In this and in other figures no attempt has been made to represent by means of an artistic effect the irregular, broken surfaces of the graftonite and associated minerals. The stippled portions of the figures are intended to represent the irregular surfaces, and, if carried out in the proper proportion in fig. 2, the stippling

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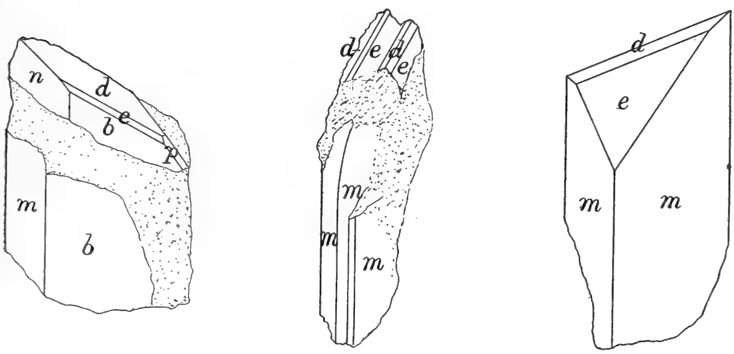

should continue for a considerable distance above and to the right, beyond the limits of the figure. Fig. 3 represents two crystals, about 7[cm] long, which have grown together in parallel position and have suffered deformation, the vertical edges and faces of the prism being decidedly curved, although the monosymmetric character of the crystal seems not to have been disturbed. No cracks, resulting from cleavage or fracture, are visible in this specimen, and no other specimen was observed which showed similar deformation. Figs. 4, 5, 6 and 7 represent fragments and corners of much decomposed crystals with rough faces. The material as a whole was very unfavorable for crystallographic study, and it is possible that the conclusions reached concerning the orientation of some of the crystals and the identification of the forms are erroneous, although, as far as could be told with the contact goniometer, the measure-

ments indicated the simple forms which have been recorded in the foregoing list.

The optical properties of the graftonite, as far as they were studied, indicate monoclinic symmetry. The lamination, as will be explained more in detail later, is parallel to the pinacoid *b*, 010, of the graftonite, and hence a section like that represented by fig. 1, cut at right angles to the lamination, is at

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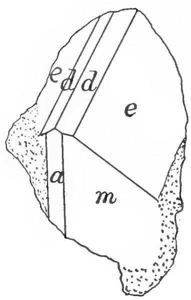

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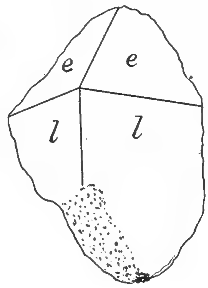

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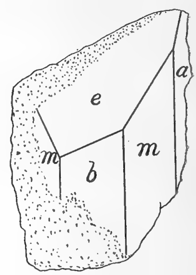


right angles to the symmetry plane. Two sections were thus prepared from the small fragment of fresh material, and, except that they were at right angles to the symmetry plane, nothing is known concerning their orientation. In these sections, when examined in polarized light, the graftonite was found to have an extinction parallel to the lamination, as indicated by the arrows, fig. 1. In one of the sections, when examined in convergent polarized light, a portion of a biaxial interference figure was observed toward the limit of the field, and the position of the figure indicated distinctly that the plane of the optical axes is at right angles to the symmetry plane, the acute bisectrix being in the symmetry plane. By mounting a small fragment of the thin section on the little axial angle apparatus devised by Professor Klein,* filling the vessel with a liquid of high index of refraction, and turning until the bisectrix came to the center of the field of the polariscope, the horizontal character of the dispersion could be distinctly seen, and it was estimated that the divergence of the optical axes, 2 V, was about 50° to 60°. The birefringence is not very strong and its character is positive.

The interlamination of two minerals such as graftonite and triphylite, differing in chemical composition and crystallizing in different systems, is an interesting and unusual phenomenon which seemed worthy of some study. Before discussing the

* Groth's Physikalische Krystallographie, 1895, fig. 690, p. 750.

problem presented by this particular intergrowth, however, it may be well to cite a few illustrations of a somewhat similar nature. The best and undoubtedly the most familiar illustration of the lamellar intergrowth of two minerals is that of albite (triclinic) and orthoclase (monoclinic), a phenomenon commonly observed in studying thin sections of rocks, and familiarly known to petrographers as the perthitic or microperthitic structure. In the case of the feldspars the two minerals are closely related both in chemical composition and crystalline form, they are united by their pinacoid faces *b*, 010, having their vertical axes parallel, and thus the cleavage directions and the interfacial angles of the two minerals conform very closely to one another. Other familiar instances of parallel, though not of lamellar intergrowth are of staurolite (orthorhombic) on cyanite (triclinic), rutile (tetragonal) on hematite (hexagonal-rhombohedral), and chalcopyrite (tetragonal) on both tetrahedrite and sphalerite (isometric). In each of these cases it is probable that the two minerals have certain molecular or crystallographic features so nearly alike that the two substances can grow together in certain definite positions, somewhat analogous to the growth of two crystals of the same material in parallel or in twin position.

Evidently the most important thing to be determined in connection with the study of the interlamination of the monoclinic graftonite and the orthorhombic triphylite is the manner in which the two minerals are intergrown. Undoubtedly the graftonite, which makes up from two-thirds to three-quarters of the total mass of the crystals, has exerted the controlling influence upon the crystalline form, for the external shape of the crystals is monoclinic and not orthorhombic. In all of the specimens the lamination is very pronounced and parallel to the clinopinacoid *b*, 010, of the graftonite; however, the surfaces by which the two minerals are united are not plane and even, like cleavage or crystal faces, but undulatory, somewhat resembling in miniature a surface presented by a slab of sedimentary rock exhibiting ripple marks. An idea of the uneven character of the surfaces may be gained by noting the irregular, wavy lines of juncture between the two minerals as seen in cross section, fig. 1. In the specimen represented by fig. 2 there was a limited area where the lamination was apparently parallel to the prism *m* of the graftonite, but in other parts of the specimen and in all other crystals the lamination was throughout parallel to the clinopinacoid *b*.

When a section like fig. 1 is examined in polarized light, the graftonite, as already stated, shows parallel extinction; the extinction of the triphylite, however, in the particular section under consideration, is inclined about 27° to the direction of

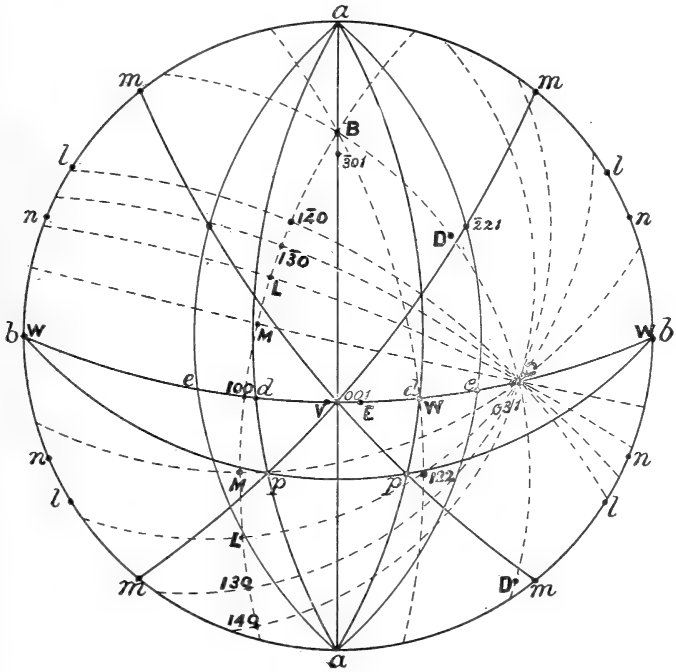
lamination, and differently in different lamellæ, as indicated by the arrows, fig. 1. In lamellæ 1, 3 and the upper part of 5 the extinction is to the right, while in 2, 6, 7 and the lower part of 5 it is to the left. Thus evidently the orthorhombic triphylite and the monoclinic graftonite have not intergrown with pinacoid faces in common, for in that case both minerals would have shown parallel extinction. The inclined extinction of the triphylite naturally suggested the idea that one of its prism or dome faces might be parallel to the clinopinacoid of the graftonite, and, on looking for some similarity between the forms and angles of the two minerals, it was observed that the angle of the macrodome 102 of triphylite ($102 \wedge \bar{1}02 =$ $62° 23'$) was practically the same as the angle between the clino-dome *d*, 011, and the clino-pinacoid *b*, 010, of graftonite ($011 \wedge 010 = 62°$). If therefore a triphylite crystal is orientated so that its macro-axis is parallel to the clino-axis of graftonite, and is then tipped 31° so that a dome face 102 comes in contact with the clinopinacoid *b* of graftonite, then the clinodome *d* of the graftonite and the macrodome of the triphylite fall practically in one plane. In trying to find other points of similarity which the two minerals might possess, recourse was had to the spherical projection. Fig. 8 represents in its full lines the spherical projection of graftonite, the location of the forms recorded on p. 24 being indicated by italic letters, while the location of four forms, 001, 031, $\bar{3}01$ and $\bar{2}21$, which were not observed as crystal faces, are indicated by indices in small figures. The projection of the triphylite is given in dotted lines, the known forms being indicated by heavy, full-faced letters, while the indices of a few possible forms are also given in heavy figures. The lettered forms of the triphylite are as follows:

B, 010	M, 110	W, 102	V, 302
C, 001	L, 120	E, 101	D, 021

As a starting point in constructing the projection of the triphylite, the zone in which 100 and C, 001, are located was made to coincide with the zone *b*, *d*, *d*, of the graftonite, and the location of two faces of the macrodome W of the triphylite to coincide, one with the clinodome *d*, the other with the clinopinacoid *b* of the graftonite. Thus, as shown by the figure, the forms C, V and 100 of triphylite correspond closely to 031, 001 and *d*, $0\bar{1}1$ of graftonite respectively. A zone W, 122, M, W of triphylite is almost coincident with that joining *b* and *p* of graftonite, though the forms M and 122 of the former are located several degrees distant from the pyramid *p* of the latter. Finally the faces of the dome D, 021 and $0\bar{2}1$, of triphylite fall one within about 3° of the prism

m, the other about 5° of a possible pyramid $\bar{2}21$ of graftonite. It must furthermore be borne in mind that the variable elements, that is, the axial ratios, of both triphylite and graftonite have been derived from measurements made with only a contact goniometer, hence the correspondence between the two minerals may be even closer than is indicated by their position as plotted on the spherical projection.

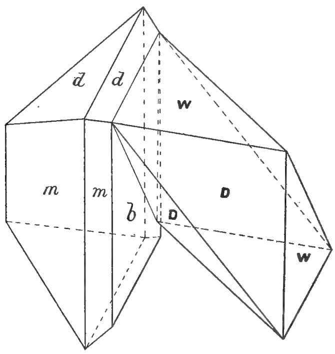
8



Another and perhaps a more convincing method of showing similarity between the two minerals is given by fig. 9. This represents at the left a monoclinic combination of the forms *m* and *d* of graftonite, with the right hand edge of the prism truncated by a clinopinacoid *b*. To the right is a triphylite crystal, representing a combination of the domes W, 102, and D, 021, accurately plotted, and drawn so that one of the W faces is in contact with the clinopinacoid of the graftonite and the edge W $\wedge$ W parallel to the clino-axis of the latter mineral. Thus drawn, a *d* face of the one crystal and a W face of the other full almost exactly in one plane (W $\wedge$ W $= 62° 23'$ and $b \wedge d = 62°$), and, also a brachydome face D of the triphylite

is almost parallel to the prismatic face *m*, 110, of the graftonite, as shown by the fact that the edges between *m* and *d* and W and D, fig. 9, form almost a continuous line, or from fig. 8, that the angle between *d* and *m* (011 $\wedge$ 110 = 54° 56′) is almost the same as that between W and D (102 $\wedge$ 021 = 53° 54′)

9



The foregoing demonstrations furnish a working hypothesis for explaining how the two minerals might possibly have grown together because of similarity in certain prominent crystallographic features, and it remains to be shown to what extent the hypothesis conforms to the structural features presented by the intergrowth of the two minerals. In fig. 10 there is represented in the center an ideal cross-section of a graftonite crystal, at right angles to the clino-axis, and showing the outlines of the forms *d* and *b*. Such a section should exhibit in polarized light parallel extinction, as is the case with the graftonite in fig. 1. On either side of the graftonite in fig. 10 are represented sections of triphylite crystals at right angles to the macro-axis *b* and so orientated that faces of the macrodome W are parallel to and in contact with the clinopinacoid *b* of the graftonite; compare fig. 9. Such sections should show extinction angles of 31° to the right and to the left of the interposed graftonite, as indicated by the arrows. The structure indicated by the ideal section, fig. 10, corresponds to the optical properties of the minerals in the section represented by fig. 1, where the interlaminated triphylite (compare lamellæ 1, 2 and 3) shows inclined extinction, symmetrically disposed to the right and to the left of the plane of lamination. If a cross section of the composite crystal were at right angles to the symmetry plane of the graftonite, but not at right angles to the clino-axis, then the extinction angles of the triphylite would be less than 31°, but still remain equal on either side of

the plane of lamination. In the section represented by fig. 1 the extinction angle of the triphylite is about 27° ; hence, if the hypothesis which is proposed is the correct one, the section should be nearly though not quite at right angles to the clino-axis of the graftonite and the macro-axis of the triphylite. Furthermore, according to the investigation of Penfield and

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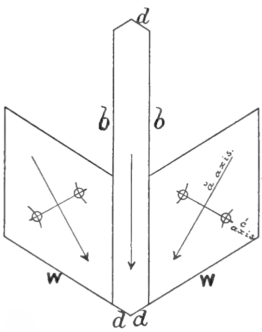
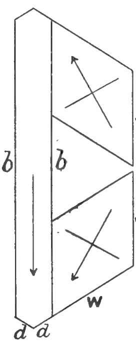


11



Pratt,* it may be assumed that in triphylite having about 33 per cent. of FeO the acute bisectrix is the *b*-axis, the plane of the optical axes being 100, as indicated by fig. 10, and the divergence of the optical axes, 2 V, about 80°. Hence in a section similar to fig. 10, at right angles to the *b*-axis of the triphylite, the latter should show a bisectrix ; while if slightly inclined, as may be assumed to be the case in the section represented by fig. 1, some portion of the interference figure ought to be visible. This in reality is the case when the tryphylite lamellæ are examined, although, owing to the character of the material, the interference figures are not very distinct. Thus the optical properties, as far as they have been made out, confirm the hypothesis that a dome face of the triphylite is in contact with a clinopinacoid face of the graftonite. Fig. 11 represents two crystals of triphylite orientated in twin position to one another upon a clinopinacoid face of graftonite. Crystals thus orientated, provided they increased in size, would have to adapt themselves to circumstances as they grew together, and the surface of contact between them would probably be irregular and not conformable to any definite crystal plane. Such a condition may have existed when lamella 5, fig. 1, was forming, for in one portion the extinction is to the right, in another to the left, while the two portions unite along an

* This Journal, III, l, p. 387, 1895.

irregular line which can be distinctly traced under the microscope.

The composite crystals of graftonite and interlaminated triphylite are large, and, therefore, it seems probable that a very long time would be required for their growth and development. It does not seem probable that the crystals could have been originally of one material and subsequently, without oxidation of the iron or manganese, have been changed in part to a material of different composition. The acceptance of such a theory would require that the product resulting from the alteration (in this case the rare mineral triphylite) should have developed as interspersed lamellæ having definite crystallographic orientation with reference to the original material. Again it does not seem probable that they were at one time wholly graftonite, and that later, by pressure or other agency, they were broken up into lamellæ, leaving interstices for the subsequent infiltration of triphylite as a cementing material. The crystals, with the exception perhaps of the one represented by fig. 3, show no evidence of having been crushed and cemented together, nor are there any inequalities, striations or offsets visible on their faces to lead one to suspect that the crystals have been opened out and broadened as a result of the interlaminated triphylite. It seems rather probable that the crystals must have developed in a solution or medium which contained the chemical constituents for the formation of both compounds, and that the growth was of such a nature that graftonite was deposited at one period and triphylite at another. Thus, according as the supply of material favorable for the formation of the one compound or the other was most abundantly at hand, the growth of the crystals proceeded until the large interlaminated individuals were formed.

It is to be regretted that only one small fragment of fresh unaltered material, without definite crystal faces, was found. The material as a whole was of such a nature that accurate crystallographic measurements could not be made, and orientated sections containing unaltered triphylite could not be prepared, hence the crystallographic relations of the two minerals have not been established with absolute certainty. It is hoped, however, that the time devoted to finding even a possible explanation of the remarkable intergrowth presented by the two minerals has not been spent in vain.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School of Yale University, November, 1899.

Art. V.—*Explorations of the "Albatross" in the Pacific Ocean;* by Alexander Agassiz.

[Extract from a letter to the Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries. Washington, D. C., dated Papeete Harbor, Tahiti Island, 30 September, 1899, on the trip of the "Albatross" from San Francisco to Papeete]

I arrived at San Francisco on August 20th, and after consulting with Commander Moser we decided to leave on Wednesday, the 23d. Everything shipped from the East had arrived with the exception of the tow nets sent me by Dr. Kramer, and the deep-sea nets kindly ordered for me by Professor Chun of Leipzig. Captain Moser and I decided not to make any soundings nor do any deep-sea work until we had passed beyond the lines of soundings already run by the Albatross and Thetis between California and the Hawaiian Islands.

In latitude 31° 10′ N., and longitude 125° W., we made our first sounding in 1955 fathoms, about 320 miles from Point Conception, the nearest land. We occupied 26 stations until we reached the northern edge of the plateau from which rise the Marquesas Islands, having run from station No. 1, a distance of 3800 miles, in a straight line.

At station No. 2 the depth had increased to 2368 fathoms, the nearest land, Guadeloupe Island, being about 450 miles, and Point Conception nearly 500 miles, distant. The depth gradually increased to 2628, 2740, 2810, 2881, 3003, and 3088 fathoms, the last in lat. 16° 38′ N., long. 130° 14′ W., the deepest sounding we obtained thus far in the unexplored part of the Pacific through which we were passing. From that point the depths varied from 2883 to 2690 and 2776, diminishing to 2583, and gradually passing to 2440, 2463, and 2475 fathoms until off the Marquesas, in lat. 7° 58′ S., long. 139° 08′ W., the depth became 2287 fathoms. It then passed to 1929, 1802, and 1040 fathoms in lat. 8° 41′ S., long. 139° 46′ W., Nukuhiva Island being about 20 miles distant. Between Nukuhiva and Houa-Houna (Ua-Huka) Islands we obtained 830 fathoms, and 5 miles south of Nukuhiva 687 fathoms. When leaving Nukuhiva for the Paumotus we sounded in 1284 fathoms about 9 miles south of that island. These soundings seem to show that this part of the Marquesas rises from a plateau having a depth of 2000 fathoms and about 50 miles in width, as at station 29 we sounded in 1932 fathoms.

Between the Marquesas and the northwestern extremity of the Paumotus we occupied nine stations, the greatest depth on

that line being at station No. 31, in lat. 12° 20′ S., and long. 144° 15′ W. The depths varied between 2451 and 2527 fathoms and diminished to 1208 fathoms off the west end of Ahii, and then to 706 fathoms when about 16 miles N.E. of Avatoru Pass in Rairoa Island.

We developed to a certain extent the width of the Paumotu Group plateau by a line of soundings in continuation of the direction of Avatoru Pass, extending a little less than 9 miles seaward, where we obtained a depth of 819 fathoms. Subsequently we ran a similar line normal to the south shore of the lagoon of Rairoa, a distance of nearly 12 miles, into 897 fathoms.

Between Rairoa and Tikehau, the next island to the westward, we got a depth of 1486 fathoms.

Between Tikehau and Mataiwa six soundings were made with a depth of 488 fathoms half a mile from shore, and a greatest depth of 850 fathoms $6\frac{1}{2}$ miles from Tikehau. The slope approaching Mataiwa is steeper than the Tikehau slope.

From Mataiwa to Makatea (Aurora) Island, we made six soundings: from 642 fathoms about $2\frac{1}{2}$ miles off shore, to 581 fathoms about $1\frac{1}{8}$ miles off the west side of the latter island, the depths passing to 860, 1257, 1762, and the greatest depth being 2267 fathoms; then 2243, and rising more rapidly near Makatea to 581 fathoms.

Between Makatea and Tahiti we made eight soundings, beginning with 1363 fathoms, 2 miles off the southern end of Makatea, passing to 2238, 2363 (the greatest depth on that line), to 2224, 1930, 1585, 775, and finally 867 fathoms off Point Venus.

These make in all 72 soundings up to the present time.

The deep basin developed by our soundings between lat. 24° 30′ N., and lat. 6° 25′ S., varying in depth from nearly 3100 fathoms to a little less than 2500 fathoms, is probably the western extension of a deep basin indicated by two soundings on the charts, to the eastward of our line, in longitudes 125° and 120° W., and latitudes 9° and 11° N., one of over 3100 fathoms, the other of more than 2550 fathoms, showing this part of the Pacific to be of considerable depth and to form a uniformly deep basin of great extent, continuing westward probably, judging from the soundings, for a long distance.

I would propose, in accordance with the practice adopted for naming such well-defined basins of the ocean, that this large depression of the Central Pacific, extending for nearly thirty degrees of latitude, be named Moser Basin.

The character of the bottom of this basin is most interesting. The haul of the trawl made at station No. 2, lat. 28° 23′ N., long. 126° 57′ W., brought up the bag full of red clay and manganese nodules with sharks' teeth and cetacean ear-bones;

and at nearly all our stations we had indications of manganese nodules. At station No. 13, in 2690 fathoms, lat. 9° 57′ N., long. 137° 47′ W., we again obtained a fine trawl haul of manganese nodules and red clay; there must have been at least enough to fill a 40-gallon barrel.

The nodules of our first haul were either slabs from 6 to 18 inches in length and 4 to 6 inches in thickness, or small nodules ranging in size from that of a walnut to a lentil or less; while those brought up at station No. 13 consisted mainly of nodules looking like mammillated cannon-balls varying from 4½ to 6 inches in diameter, the largest being 6½ inches. We again brought up manganese nodules at the equator in about longitude 138° W., and subsequently—until within sight of Tahiti—we occasionally got manganese nodules.

As had been noticed by Sir John Murray in the Challenger, these manganese nodules occur in a part of the Pacific most distant from continental areas. Our experience has been similar to that of the Challenger, only I am inclined to think that these nodules range over a far greater area of the Central Pacific than had been supposed, and that this peculiar manganese-nodule bottom characterizes a great portion of the deep parts of the Central Pacific where it cannot be affected by the deposits of globigerina, pteropods, or telluric ooze; in the region characterized also by red-clay deposits. For in the track of the great equatorial currents there occur deposits of globigerina ooze in over 2400 fathoms for a distance of over 300 miles in latitude.

Manganese nodules we found south of the Marquesas also, when in 2700 fathoms we obtained perhaps the finest specimens of red clay from any of our soundings. As we approached close to the Western Paumotus, upon the north side of the plateau from which they rise, globigerina ooze passed gradually to pteropod ooze, then to fine and coarse coral sand. In the channel south of the Paumotus to Tahiti the coral sand passed to volcanic sand mixed with globigerinæ in the deepest parts of the line, and toward Tahiti passed to volcanic mud mixed with globigerinæ, next to fine volcanic sand, and finally, at the last sounding, off Point Venus, to coarse volcanic sand.

We made a few hauls of the trawl on our way, but owing to the great distance we had to steam between San Francisco and the Marquesas (3800 miles) we could not, of course, spend a great deal of time either in trawling or in making tows at intermediate depths. Still the hauls we made with the trawl were most interesting, and confirmed what other deep-sea expeditions have realized: that at great depths, at considerable distances from land and away from any great oceanic current, there is comparatively little animal life to be found. Where

manganese nodules were found the hauls were specially poor, a few deep-sea holothurians and ophiurans, and some small actiniæ which had attached themselves to the nodules with a few other invertebrates, seemed to be all that lived at these great depths, 2500 to 2900 fathoms, far away—say from 700 to 1000 miles—from the nearest land.

The bottom temperatures of the deep (Moser) basin varied between 34·6° at 2628 and 2740 fathoms, to 35·2° at 2440 fathoms, and 35° at 2475 fathoms; about 120 miles from the Marquesas. At station No. 23, off the Marquesas, in 1802 fathoms, the temperature was 35·5°.

Owing to the failure of our deep-sea thermometers we were nót able to make any satisfactory serial-temperature observations. At station No. 11, lat. 14° 38′ N., long. 136° 44′ W., we obtained:

79°	at surface		
78·7°	at	50	fathoms
55·9°	"	100	"
48·9°	"	200	"
44·1°	"	300	"
39·9°	"	700	"

These temperatures are somewhat higher than those obtained by the Challenger in similar latitudes on their line to the westward of ours between the Sandwich Islands and Tahiti.

The temperatures of the bottom between the Marquesas and Paumotus were 34·9° at 1932 fathoms, 35° at 2456 fathoms and 2451 fathoms, and 35·1° at 2527 fathoms.

We did not take any bottom temperatures between the Paumotus and Tahiti.

Our deep-sea nets not having reached San Francisco at the time we sailed, we limited our pelagic work to surface hauls, of which we generally made one in the morning and one in the evening, and whenever practicable some hauls with the open tow nets at depths varying between 100 and 350 fathoms. The results of these hauls were very satisfactory. The collection of surface animals is quite extensive, and many interesting forms were obtained. As regards the deeper hauls, they only confirm what has been my experience on former expeditions, that beyond 300 to 350 fathoms very little animal life is found, and in the belt above 300 fathoms, the greater number of many so-called deep-sea crustaceans and deep-sea fishes were obtained. I may mention that we obtained Pelagothuria at about 100 fathoms from the surface.

We trawled at station No. 10 in 3088 fathoms. Unfortunately the trawl was not successful, and we simply hauled the bag through over 3000 fathoms without bringing up a single deep-sea animal from intermediate depths which we did not

obtain quite near the surface—at less than 300 fathoms. I may mention here that the experience of the Valdivia shows, from the preliminary reports published by Professor Chun, that no pelagic algæ extend to beyond about 150 fathoms. Although he also states that animal life is found at all depths from the surface to the bottom, yet he states that beyond 800 meters it diminishes *very rapidly;* Professor Chun does not state whether this diminution is more rapid away from land than near continental areas, both of which conditions I had called especial attention to in my Preliminary Report on the Albatross expedition of 1891, while using the Tanner net in the Gulf of California. Mr. George Murray has criticized the action of the Tanner deep-sea net, and condemns its results, suggesting that the bottom net had always closed some time after being sent down. I need not now discuss that subject, but will only refer him to the report of the Albatross, in which he will find the closed part of the net to have on several occasions brought up (when I expected it to do so) specimens from over 600 fathoms from immediately above the bottom, or samples of the bottom from near 1700 fathoms while attempting to tow immediately above that depth. I ought, in justice to him, to state that I omitted to mention that we secured the loops by twine to the detacher to insure their dropping only when the messenger reached the detacher, and that the hooks of the detacher were lengthened very considerably above the dimensions figured in my Preliminary Report on the Albatross expedition of 1891. I might add that we made a number of trials near the surface to see the action of the Tanner net under all conditions of position and speed, and I can only assume that Mr. Murray, having no experience, did not handle his net properly, or that it was not properly balanced. I may also add that Captain Tanner used his modified net subsequently in the Albatross, while running a line of soundings from San Francisco to the Hawaiian Islands, in from 100 to 350 fathoms from the surface, at considerable distances from the islands and the mainland, and also in Alaskan waters, and always with the results we had obtained before. The closed bag, when towing at 100 fathoms below the surface, always brought up a mass of pelagic animals living at about that depth, while when tried at 300–350 fathoms it brought up little or nothing. There is nothing in Captain Tanner's experience, or mine, to indicate why the net should act well at 100 fathoms and not well at 300 fathoms or more, as suggested by Mr. Murray.

On our way to Tahiti from the Marquesas we stopped a few days to examine the westernmost atolls of the Paumotus. Striking Ahii we made for Rairoa, the largest atoll of the

Paumotu group. Skirting the northern shore from a point a little west of Tiputa Pass, we entered the lagoon through Avatoru Pass, anchoring off the village. This pass is quite narrow, with a strong current running out the greater part of the time, especially in easterly winds. It varies in depth between 9 and 10 fathoms, shoaling near the inner entrance to about 3½ fathoms, and deepening again to 6 or 7 fathoms, and gradually passing into 15 to 17 fathoms, which is the average depth of the lagoon from Avatoru Pass to the south or weather shore, a distance of about 13 miles.

We made an examination of the northern side of the lagoon between Avatoru and Tiputa Passes. The lagoon beach of the northern shore is quite steep, and is composed of moderately coarse broken coral sand at the base, and of larger fragments of corals along the upper face, which is about 5 to 6 feet above high-water mark. These coral fragments are derived in part from the corals living on the lagoon face of the northern shore, and in part of fragments broken by the waves from somewhat below the low-water mark. The ledge which underlies the beach crops out at many places on the lagoon side of the northern shore; we traced it also along the shores of Avatoru Pass, and about half way across the narrow land running between Avatoru and Tiputa Passes. It crops out also at various points between them in the narrow cuts which divide this part of the northern land of the lagoon into a number of smaller islands. These secondary passes leave exposed the underlying ledge, full of fossil corals. In some cases there is left a clear channel extending across from the lagoon to the northern side through which water flows at high or half tide. In other cases the cuts are silted up with coral sand blown in from the lagoon side. In others, the cut is shut off by a high sand-bank, or a bank composed of broken fragments of corals, leaving access to the water from the northern shore only; and finally the cuts are also shut off on the northern side by sand and broken coral banks, the extension of the north-shore beach leaving a depression which at first is filled with salt-water and gradually silted up both from the lagoon side and the sea side, and forms the typical north-shore land of the lagoon. This building up of the land of the Paumotu atolls simultaneously both by the accumulation of sand from the lagoon side and the sea face, is very characteristic of the atolls of that group. It is a feature which I have not seen so marked in any other coral reef district.

On the lagoon side the slope from the beach is very gradual into 16 and 17 fathoms, and corals appear to flourish on the lagoon slope to 6 or 8 fathoms only, in some cases consisting of Madrepores, Porites, Astræans and Pocillopores. The corals

could be seen over the floor of the Avatoru passage down to from 9 to 10 fathoms; and on the sea face Pocillopores covered the outer edge of the shore platform. This platform is from 200 to 250 feet wide, and was formed by the planing off of the seaward extension of the ledge cropping out in the cuts.

It became very evident, after we had examined the south shore of the lagoon, that the ledge underlying the north shore is the remnant of the bed, an old Tertiary coralliferous limestone which at one time covered the greater part of the area of the lagoon, portions of which may have been elevated to a considerable height. This limestone was gradually denuded and eroded to the level of the sea. Passages were formed on its outside edge, allowing the sea access to the inner parts of the lagoon. This began to cut away the inner portions of the elevated limestone, forming large sounds, as in the case of Fiji atolls, and leaving finally on the south side only a flat strip of perhaps 2,500 to 3,000 feet width which has gradually been further eroded on the lagoon side, and also on the sea face to leave only a narrow strip of land about 1,000 feet in width and perhaps 10 to 14 feet in height, the material for this land having come from the disintegration of the ledge of Tertiary limestone, both on the sea face and the lagoon side.

There exist in the lagoon a number of small islets which also consist of this same Tertiary limestone in process of disintegration and transformation to coral sand islets. They are the islets at the lagoon side of both Avatoru and Tiputa Passes, the two islets which we found along our line of soundings, the one about 4½ miles from the north side of the lagoon, and the other about the same distance from the south shore. I am told that the eastern extremity of the lagoon is filled with islets and heads consisting of the same limestone rock so characteristic of the north and south shores of the lagoon.

The underlying ledge is not the remnant of a modern reef; its character is identical with that of the elevated limestones of Fiji, which are of Tertiary age, and the rock is in every respect the same as that I observed on many of the elevated islands of Fiji. The atoll of Rairoa is in a stage of denudation and erosion very similar to that of Ngele Levu, in Fiji, only in Ngele Levu the elevated limestone attains a height of about 60 feet. Our visit to the south shore of the lagoon, both on the lagoon side and on the sea face, left us no doubt regarding the character of the underlying ledge of the north shore. As soon as the south shore was sufficiently near, as seen from the lagoon side, for us to distinguish its character, we could see that the entire shore line was formed of a high ledge of lime-

stone, honeycombed, pitted and eroded, both by atmospheric agencies, and the action of the waves, in its lower parts both on the lagoon side and on the sea face. The great rollers of the weather side broke through between the columnar masses of the ledge into the lagoon, and as far as the eye could reach there extended a more or less continuous wall (which is described by Dana as he saw it sailing by in the Vincennes). But in addition to this we found, on landing, this wall to be the sea face of the islands and islets which dot the weather side for the greater part of its length on the southwestern part of the lagoon.

These islands and islets are entirely composed of coral sand and coral fragments, formed from the disintegration of the extension of the elevated ledge toward the inside of the lagoon to a distance of about 1½ to 2 miles; and along this very gradual slope of the islands forming the southern edge of Rairoa, corals grow profusely down to 6 or 7 fathoms of water, when the bottom runs into hard coralline bottom similar to that found on all the soundings taken across the lagoon.

The width of the larger islands is about 1000 to 1200 feet; the smaller islands and islets are less, some of the latter forming in reality mere sand buttresses at right angles to the great limestone ledge which flanks them all on the sea face and connects them on the weather side as if by a great wall, more or less broken, and shuts off the communication of the interior of the lagoon with the sea on that side.

The passages between the islands and islets illustrate well, only on a larger scale, the formation of the cuts, more or less silted up, which were observed on the northern face of the lagoon. Some of these passages are dry at low-water, others are partly filled by tide pools, others are entirely silted up by lagoon sand, only they are lower than the sand-blown land of the islands on either side of it.

Crossing over to the weather side of the southern land of Rairoa in one of the passages between two of the islands, we came upon the limestone ledge, from 12 to 14 feet high and about 40 to 50 feet wide, which formed the sea face of the islands and islets, and extended far to the westward as a great stone wall more or less broken into distinct parts. We found this ledge to consist of elevated limestone as hard as calcite, full of corals, honeycombed and pitted, and worn into countless spires and spurs, and needles and blocks of all sizes and shapes, separated by deep crevasses or potholes recalling a similar scene in Ngele Levu on the windward end of the lagoon. In the passages the parts of the ledge which had not been eroded, extended as wide buttresses, gradually diminishing in height till they formed a part of the lagoon flat and extended out below the recent beach rock which covered it in short stretches.

The slope of the sea face of the elevated ledge was quite steep and similar to the lagoon slope, and its upper surface weathered by atmospheric and aqueous agencies into all possible shapes such as I have mentioned. The slope passed into the shore platform, which was shaved down as it were to a general level surface. On the outer edge, within the line of the breakers, were growing Pocillopores in great abundance. This reef flat or shore platform, as well as the reef platform of the north shore, was strewn here and there with huge masses of the ledge of elevated reef rock torn from its outer shore. Similar rocks and bowlders occur on the lagoon side of the islands forming the outer lands of Rairoa; they are either torn off from the lagoon face of the outcropping ledge, or are parts of the ledge which have remained in place and have not been planed down to the base level of the reef.

The amount of water which is forced into such a lagoon as Rairoa is something colossal, and when we observe that there are but a small number of passages through which it can find its way out again on the leeward side, it is not surprising that we should meet with such powerful currents (7 to 8 knots in several cases) sweeping out of the passages on the lee sides.

The islands and islets of Rairoa are fairly well covered with low trees and shrubs and large groves of palm trees.

The atolls of Tikehau and Mataiwa, which we also examined, present no features which we did not meet in Rairoa. The first-named atoll shows the same method of formation of the land by material piled up both from the lagoon side and the sea face; material derived from the disintegration of the underlying Tertiary limestone which crops out here and there along the sea face and the inner shores of the lagoon, or forms across the S.W. face of the lagoon an irregular disconnected part of the ring of islands and islets encircling that end of the lagoon. These islets and islands are more or less connected by fragments of the elevated limestone ledge, attesting its greater extension in past times. The outer rings of both these atolls are covered with vegetation. We could see in the lagoons several rocky islets, the fragments of the elevated limestone ledge.

Mataiwa is interesting, as its lagoon is quite shallow; it is full of rocky islets, remnants of the underlying limestone ledge which crops out above the general level, and has a very narrow and shallow entrance, passable for boats only. Some of its islands are wooded and appear to have been formed by accretion of sand from the decomposing ledges of the lagoon. The outer ring of land appears formed by sand banks driven in from the sea face and driven out from the lagoon side by the action of the waves. It is evident that such a lagoon as

Mataiwa could readily be closed to any access to it by the sea, as it now has only one very narrow and very shallow boat passage connecting the lagoon with the sea on the lee side.

It was with great interest that we approached Makatea, as it is the only high elevated island of which Dana speaks as occurring in the western Paumotus. For though he mentions some others as possibly having been elevated 5 to 6 feet, yet he considered them all, as well as Makatea (Metia or Aurora, of Dana) as modern elevated reefs. Yet from the very description given by him of the character of the cliffs and of the surface of Makatea, I felt satisfied that it was composed of the same elevated coralliferous limestone so characteristic of the elevated reefs of Fiji, and which from the evidence of the fossils and the character of the rock, both Mr. Dall and myself have been led to regard as of Tertiary age.

As we approached the island from the northwest it soon became evident that it presented all the characteristics to which I had become so accustomed in Fiji, and, upon landing, this was found to be the case. The cliffs had the same appearance as those of Vatu Leile, Ongea, Mango, Kambara, and many other elevated islands of Fiji. There were fewer fossils perhaps, but otherwise the petrographic character of the rock was identical with that of Fiji. Mr. Meyer collected upon the top of the second terrace a number of fossils similar in all respects to those we found in the Fiji elevated coralliferous limestones.

The southwestern extremity of the island sloped gradually to the sea and showed two well-defined terraces. The lines of these two terraces could, as a rule, be traced along the faces of the vertical cliffs by the presence of caverns along the lines of those levels, similar to the lines of caverns indicating the line of present action of the sea at the base of the cliffs. As we steamed around the island there were distinct indications of two additional terraces on the line of the vertical cliffs on the weather side of the island. The position of these terraces was usually more clearly seen along the face of the cliffs at prominent points where they were undercut much as I have figured them for certain cliffs in Vatu Leile, in Fiji, in my report on the islands and coral reefs of that group.

Of course it is premature, from this examination of the western extremity of the Paumotus, to base any general conclusions regarding the mode of formation of those atolls; certainly as far as I have gone there is absolutely nothing to show that the atolls of the Paumotus have not been formed in an area of elevation similar to that of Fiji. The evidence in Rairoa and in the atolls of the western Paumotus is very definite. Makatea is an elevated mass of coralliferous limestone similar in all respects to masses like Vatu Vara, Thithia, and

others in Fiji. Like them, Makatea is surrounded by a comparatively narrow shore platform cut out from the base of the limestone cliffs and on the seaward extension of which corals grow abundantly to depths of 7 to 8 fathoms, when they appear to become very much less numerous. So that it is not unnatural to look upon the area of the Paumotus, as I am inclined to do, as one of elevation, the raised and elevated land of which has been affected much in the same way by denudation and by erosion, as have the masses of elevated coralliferous limestone of Fiji. Only, there seems to have been, from the evidence thus far presented a far greater uniformity in the height of the elevation of the Paumotus. This would render the explanation I have given less evident had I not the experience of the Fiji group to guide me. I am informed that there are other islands and atolls in the Paumotu group showing traces of this elevation, so that I am at any rate justified in denying that the Paumotus as such are situated in an area of subsidence, and that subsidence has been the great factor, as is maintained by Darwin and Dana, in the formation of the characteristic atolls of the group.

It may be well to point out also that the Paumotus, like the Marquesas on one side and the Society Islands on the other, are situated upon a plateau similar to that upon which the last mentioned groups are placed, a plateau rising from a general oceanic basin which surrounds them and which has a depth of from 2300 to 2500 fathoms, the plateau itself having a depth of 1200 to 1500 fathoms. Furthermore, evidence of this elevation is found at the two extremities of the Paumotu Plateau, at Makatea, an elevated island consisting of Tertiary coralliferous limestone, and at Gambier Islands, which are volcanic islands of considerable height.

Art. VI.—*Some Analyses of Italian Volcanic Rocks*, II; by Henry S. Washington.

[Continued from p. 294, vol. viii.]

Ciminite, Monte Cimino, Viterbo.—In 1896* I described certain trachytic rocks from this region, giving them the name of ciminite, derived from this locality, where they are found in typical development. They are composed essentially of alkali and lime-soda feldspars, augite and olivine, the presence of the last mineral and their more basic character distinguishing them from the closely related vulsinites. Both from a chemical and mineralogical point of view they stand intermediate between the trachytes and the andesites and basalts, and are hence monzonitic in character. They belong to the group which Rosenbusch has called andesitic trachytes and trachydolerites† and for which Ransome‡ has proposed the name of latite.

As another analysis seemed desirable to establish the type more definitely, one was made of a specimen from a flow at La Colonetta, on the south slope of Monte Cimino. It is rather dark gray, dense and compact, with some vesicles. A few phenocrysts of glassy feldspar (orthoclase and labradorite), augite and olivine are visible. In thin section it resembles those already described, though olivine phenocrysts are somewhat more abundant, and the groundmass is denser, with a felt of minute orthoclase and some labradorite laths lying in a glassy base.

	I	II	III
SiO_2	57·31	55·44	55·46
TiO_2	0·40	0·16	0·16
Al_2O_3	14·71	18·60	15·36
Fe_2O_3	1·21	2·09	1·34
FeO	4·37	4·48	4·50
MnO	trace	trace	trace
MgO	7·80	4·75	7·90
CaO	6·90	6·76	6·69
BaO	none	----	----
Na_2O	1·35	1·79	1·79
K_2O	6·38	6·63	6·63
H_2O (110°−)	0·18	0·25	0·15
H_2O (110°+)			0·23
P_2O_5	----	trace	trace
	100·61	100·95	100·21

* Jour. Geol., iv, p. 834, 1896; also v, p. 351, 1897.
† Rosenbusch, Elemente der Gesteinslehre, p. 339, 1898.
‡ Ransome, this Journal, vol. v, 355 and 364 ff, 1898.

I. Ciminite. La Colonetta, Monte Cimino.
II. Ciminite. Fontana Fiescoli,* Monte Cimino. Jour. Geol., iv, p. 837, 1896.
III. Ciminite. Fontana Fiescoli, Monte Cimino. New analysis.

The analysis (I) shows very clearly the intermediate character of these rocks in its medium SiO_2, rather low Al_2O_3, and high MgO, CaO and K_2O, which, taken together, are neither characteristic of an andesite or basalt on the one hand nor of a trachyte on the other. Since the rock is not holocrystalline a determination of the relative mineralogical composition is not perfectly sure, but a calculation based on the analysis indicates that, if the crystallization had been complete, the composition would have been as follows:

Orthoclase	37·9
Labradorite (Ab_4An_5)	26·5
Diopside	16·5
Olivine	17·3
Magnetite	1·8
	100·0

For comparison the original type analysis is reproduced in II. It will be seen that the two resemble each other in all particulars, except in Al_2O_3 and MgO, which are respectively lower and higher in the latest analysis. Suspicion was naturally aroused that in the older analysis, which, it may be mentioned, was the first complete rock analysis made by me, part of the MgO had been thrown down with the Al_2O_3 and Fe_2O_3. This is a mistake which is frequently made by chemists inexperienced in rock analysis, and one to which attention has been called by Pirsson,† Hillebrand‡ and myself.§

This supposition has been confirmed by a partial analysis, recently made, with an especially careful redetermination of MgO, several precipitations with NH_4HO in presence of sufficient NH_4Cl being made. In basic rocks a sodium acetate precipitation is always advisable. The results of this, combined with the reliable determinations of the first analysis, are given in III. This new analysis, it will be seen, corresponds very closely with that of the rock from La Colonetta, so that the chemical character of the type is well fixed.

It is with mixed feelings that I thus repudiate a former analysis, but the experience is of service to myself, as well as

* In former papers this name was erroneously given as "Fiesole," following an incorrect Austrian map. The spelling "Fiescoli" is that used on the Italian government maps.

† Pirsson, Jour. Geol., iv. p. 688, 1896.

‡ Hillebrand, Bull. 148, U. S. G. S., p. 39, 1897.

§ Washington, Jour. Geol., vii, p. 463, 1899.

to others, it is to be hoped, in emphasizing the necessity for extreme care in the determination of MgO, the neglect of which has rendered unreliable, as regards Al_2O_3 and MgO, many an otherwise good analysis.

"*Mica-trachyte*" (*Selagite*), *Monte Catini, Tuscany.*—The occurrence of this interesting rock forms part of a small hill, southwest of Volterra, with an area of about half a square kilometer. A rough columnar structure is quite evident. According to Reyer* the rock forms a surface flow, while according to Lotti,† with whose conclusions my own observations agree in the main, it forms a sort of stock or volcanic neck, which has come up through Tertiary marls. The age of the intrusion is undoubtedly Post-Eocene, and very probably Post-Pliocene, since marls apparently of this age have been altered at the contact.‡ Copper ores (erubescite, chalcopyrite, chalcocite, etc.) are mined in the vicinity, they occurring in connection with dikes of diabase or gabbro. The most abundant salt springs of Italy, from which the government obtains the greater portion of the salt used in the kingdom, are in the Val di Cecina near by.

The rock has long been known, having been described by Haüy,§ who named it "selagite," by which name it has been called by Italian geologists. Briefly noticed by various writers, it was first accurately described by Rosenbusch‖ in 1880, to whose description but little can be added.

The rock specimens show very many brown biotite flakes scattered through a dull, somewhat earthy, fine-grained, greenish-gray groundmass, giving it much the appearance of a minette. Under the microscope, sections show phenocrysts of biotite in large thin plates. These are of a rather pale pinkish or yellowish brown color, and are not very pleochroic. Many of them are quite colorless at the center, and occasionally one sees what seems to be a skeleton development, at the borders, producing, in basal sections, a fringe of small irregular hexagonal forms about the edges of the solid, and generally lighter colored, interior.

The groundmass is composed of small colorless crystals and anhedra of diopside, some green, fibrous, pilitic pseudomorphs after olivine, none of the original mineral being detected, and long narrow laths of feldspar, which is unstriated, and generally extinguishes parallel to the long axis, but which the investigations of Rosenbusch showed to be of both alkali-

* Reyer, Aus Toskana, Wien, 1884, p. 55.

† Lotti, Boll. R. Com. Geol. Ital, 1884, p. 36, and fig. 1, pl. viii.

‡ Lotti, Boll. R. Com. Geol. Ital., 1885, p. 254.

§ Cf. Zirkel, Lehrbuch, ii, p. 386, 1894, and Loewinson-Lessing, Petr. Lex., p. 213, 1894.

‖ Rosenbusch, Neues Jahrb, 1880, ii, p. 206.

feldspar and oligoclase. The amount of lime found on analysis indicates that the latter is present in considerable quantity. The feldspars are frequently branched and tend to assume keraunoidal forms. This is especially well seen in specimens near the contact with the marls, in which, although much decomposed, the branching of the feldspars (here more slender) is well developed. A few stout irregular grains of quartz (apparently secondary) and small apatites and magnetites are present, but are not common. Scarcely any true glass could be made out with certainty.

Even the freshest specimens from newly quarried large blocks are somewhat decomposed, since the olivines are all entirely altered to pilite, but the diopside, the feldspars, and apparently the biotite, are quite unaltered, so that it is probable that the analysis represents very well the composition of the fresh rock. This, made on the freshest piece obtainable at the quarry of Signor Ireneo Capelli, is given in I.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	56·39	55·69	56·19	58·21	41·43	53·70	57·37	55·17
TiO_2	2·07	trace	0·69	trace	0·29	1·92	----	----
Al_2O_3	12·88	19·08	16·76	19·90	9·80	11·16	13·84	13·49
Fe_2O_3	2·36	4·07	3·05	4·07	3·28	3·10	2·44	3·10
FeO	3·54	3·26	4·18	0·87	5·15	1·21	3·44	3·55
MnO	trace	trace	0·10	trace	----	0·04	trace	0·39
MgO	7·83	3·41	3·79	0·98	13·40	6·44	6·05	8·55
CaO	4·06	6·87	6·53	3·58	16·62	3·46	5·53	3·15
Na_2O	1·30	2·89	2·53	2·57	1·64	1·67	1·53	4·43
K_2O	7·84	4·41	4·46	9·17	7·40	11·16	4·47	1·09
H_2O (110°−)	1·33	0·17	0·34	0·74	1·11	0·80	3·17	4·27
H_2O (110°+)			0·66			2·61		
P_2O_5	----	----	0·55	----	none	1·75	0·37	----
CO_2	----	----	----	----	----	----	0·67	3·27
	99·60	99·85	100·02*	100·09	100·12	100·40†	100·01‡	100·46

I. Selagite ("Mica-trachyte"), Monte Catini, Tuscany. Washington anal.
II. Biotite-vulsinite, Monte Santa Croce, Rocca Monfina. Washington anal. Jour. Geol., v, p. 252, 1897.
III. Augite-latite, Table Mountain, Sierra Nevada, Cal. Hillebrand anal. Turner, 14th Ann. Rep. U. S. G. S., p. 491, 1894.
IV. Vulsinite, Bolsena, Washington anal. Jour. Geol., iv, p. 552, 1896.
V. Venanzite, San Venanzo, Umbria, Rosenbusch, op. cit. infra., p. 113.
VI. Wyomingite, Leucite Hills. Hillebrand anal. Cross, this Journal, iv, p. 130, 1897.
VII. Minette, Kirschhäuser Thal. Odenwald, Lepsius in Zirkel, Lehrbuch, ii, p. 349, 1894.
VIII. Verite, Osann anal., Zeit. deut. Geol. Ges., xli, p. 311, 1889.

The noteworthy features of this are the medium SiO_2, high MgO, K_2O and TiO_2, moderate CaO and low Al_2O_3 and Na_2O. Its essentially monzonitic or latitic character, and the resem-

* Including 0·19 BaO and trace of SrO.
† Including 0·04 Cr_2O_3, 0·62 BaO, 0·19 SrO, 0·06 SO_3, 0·03 Cl, and 0·44 F.
‡ Including 1·13 FeS_2 and trace SO_3.

blance to some analyses of minettes are at once evident, though these last usually show less silica. It may be noted in this connection that Rosenbusch* has already spoken of it as "a younger equivalent of certain minettes." The nearest approach to it among the various minette analyses which I have examined is that of Lepsius of a dike in the Odenwald, as given in VI, which, although somewhat decomposed and with notably lower potash, is of essentially the same character. Another rock with which this may be compared† is the verite of Osann (VIII), in which, however, the alkalies are in inverse ratio.

But it is of special interest to compare the rock at present under discussion with others from its own region. That with which it presents the closest analogies are the ciminites,‡ the analyses of which have just been given. Although they differ to a small extent in certain particulars, as in TiO_2, Al_2O_3, CaO and Na_2O, yet the general correspondence is remarkably close. This is of interest since they differ considerably in mineralogical composition, the abundant and prominent biotites of the Tuscan rock being entirely absent in the ciminite, while the latter carries a plagioclase richer in lime, more abundant olivine and orthoclase, and less augite. They form another addition to the growing list of cases of magmas of similar chemical composition solidifying under diverse conditions to form quite different mineral aggregates.

With this may also be compared the so-called biotite-vulsinite of Rocca Monfina, the analysis of which is given in II. This has been described elsewhere,§ but it may be recalled that it is composed of alkali-feldspar and labradorite, biotite and diopside, with no olivine. The analysis, as compared with I, shows higher Al_2O_3 and CaO, and lower MgO and K_2O, standing between those of the Monte Catini rock or the ciminites and those of the vulsinites, one of which is given for comparison in IV. While in II, Al_2O_3 may be a trifle high and MgO a trifle low, yet the analysis corresponds so well with the appearance of the rock in thin section that it may be regarded as quite trustworthy. The absence of olivine correlated with lower MgO is of especial importance. There was sufficient MgO in the selagite magma to allow the formation of olivine after the crystallization of the biotite, while in the biotite-vulsinite the early formation of this mineral and augite used up all the available supply. As regards the olivine-bearing ciminites, attention has already been called to the fact that

* Rosenbusch, Neues Jahrb., 1880, ii, p. 206.

† Rosenbusch (Elem. Gesteinslehre, 1898, p. 301) has already noted the resemblance between the two rocks.

‡ The probability of this close resemblance has been already suggested. (Jour. Geol., v, p. 354, 1897.)

§ Jour. Geol., v, p. 251, 1897.

in effusive magmas the potential biotite molecule seems to tend to split up, yielding olivine and orthoclase,* which would explain the main differences between the ciminite and selagite.

Indeed, we have in these rocks excellent illustrations of this tendency of the complex biotite molecule to crystallize as biotite in intrusive masses, while it splits up into olivine and either orthoclase or leucite in extrusive flows. The ciminites are all flows, so far as have been observed, while the chemically identical selagite forms, as has been said, a stock or volcanic neck. Exactly parallel with these are the biotite-vulsinite of Rocca Monfina (II), and the augite-latite of Table Mountain in California (III), which has been described by Turner† and Ransome.‡

The former, rich in biotite and without olivine, forms either a domal eruption which took place in the already eroded or exploded volcano, as was formerly suggested,§ or the last upwelling of lava, which plugged up the conduit of the volcano, and hence solidified under conditions analogous to those obtaining in an intrusive mass. The erosion of this volcano has been so extensive that this is quite possible, and, in view of later observations, seems to me the more probable. The latter rock is composed essentially of labradorite, augite and olivine, and a glass, which, from the analysis, would have crystallized largely as orthoclase and is quite free from biotite. The extremely close parallelism of the two analyses is certainly remarkable, and strongly suggestive of this idea, that the diverse mineralogical compositions were determined by diverse conditions of solidification.

Another rock of interest in this connection is one from San Venanzo in Umbria, recently described by Sabatini‖ under the name of venanzite, and later by Rosenbusch,¶ who calls it euktolite. It is an effusive, olivine-melilite-leucite rock, with accessory biotite. The analysis, as given by Rosenbusch, is reproduced in V. Although the venanzite is mineralogically quite different, and chemically much more basic, yet the close analogy between the two will be evident on comparing the analyses. They both show the same features of low Al_2O_3 and Na_2O, and high MgO, CaO and K_2O; i. e., in their general characters they are both monzonitic, or theralitic, as Rosenbusch prefers to call it.

* Iddings, Bull. Phil. Soc. Wash., xii, pp. 166, 172, 1892; Bäckström, Geol. För. Förh., xviii, p. 155, 1896; Pirsson, Jour. Geol., iv, p. 687, 1896; Washington, Jour. Geol., v, 359, 1897.

† Turner, 14th Ann. Rep. U. S. G. S., p. 491, 1894.

‡ Ransome, this Journal, v, p. 361, 1898.

§ Jour. Geol., v, p. 244, 1897.

‖ Sabatini, Boll. R. Com. Geol. Ital., 1898.

¶ Rosenbusch, Sitz. ber. Berlin, Akad., vii, p. 110, 1899.

The close correspondence, chemically, of venanzite with the madupite of the Leucite Hills in Wyoming was pointed out by Rosenbusch, and it is very interesting to observe that the analysis of selagite is very similar to those of wyomingite and orendite from the same region. An analysis of wyomingite is given in VI, and, although a little lower in SiO_2 and Al_2O_3, and considerably higher in K_2O, yet the general chemical resemblance between the two magmas is obvious. Wyomingite, it will be recalled,* is composed of leucite, phlogopite and diopside, and hence differs considerably from the selagite in mineralogical composition.

It may seem at first sight that, since the wyomingite is at the same time a flow and rich in phlogopite, this analogy in chemical composition militates against the views on the splitting up of the biotite molecule which have just been expressed. Examination of the analyses involved, however, shows that, while that of wyomingite is similar in general character, it differs from the others in important particulars. It is, especially as compared with the ciminite analysis given on page 44, lower in SiO_2, Al_2O_3, and at the same time very much higher in K_2O. The consequence of this would be that as there was not enough Al_2O_3 to satisfy all the K_2O, the surplus of this conditioned the formation of the potash-mica, phlogopite.

As an instance of the complexity of these problems the case of the biotite-augite-latites may be mentioned, which have been described by Ransome in the paper cited above. While these also resemble in general features the other analyses, yet they differ in the much higher content of SiO_2, this being 61 to 66 in analyses quoted by him.† Here we have, apparently, the additional factor introduced of the tendency of biotite to form in the more acid magmas, while augite forms in the more basic, but otherwise analogous, magmas.

It is evident from the foregoing that the name of mica-trachyte is a misnomer, both chemically and mineralogically, and that andesite is equally inappropriate. While the rock is chemically equivalent to the ciminites, yet the abundant biotite, which gives it a characteristic lamprophyric appearance, serves to distinguish it sharply from these, and at the same time its more basic composition and content of olivine separate it from the vulsinites. It would seem then advisable to revive for it Haüy's old name of selagite, meaning thereby a latitic rock, of lamprophyric appearance or structure, composed essentially of alkali and soda-lime feldspars, biotite, diopside and olivine, and with a chemical composition approximating to that

* Cf. Cross, this Journal, iv, p. 138, 1897. He remarks on its lamprophyric character.

† Ransome, op. cit., p. 363.

of the analysis here given. It might also, with propriety, be called a minette, though it is rather acid for this, and the name is at present generally applied to rocks occurring in dikes.

Andesite, Radicofani, Tuscany.—Northeast of Lake Bolsena, and east of Monte Aniata, there rises through the Pliocene marls a volcanic plug or neck, which forms a steep hill, crowned with a ruined castle, and with the small village of Radicofani at its southern foot. It resembles very much the volcanic necks of Uvalde County, Texas, as described by Hill and Vaughan.*

The neck is composed for the most part of a dense black, basaltic-looking rock, which is light gray and andesitic in places, while at the top of the hill it is reddish and highly vesicular.† A columnar structure is shown here and there, but it is not highly developed. The accumulation of talus at its base absolutely forbids any study of the contact, but no signs of metamorphism were visible in the marls outside the talus slope.

The locality and the rock have been described by vom Rath,‡ Bucca§ and Mercalli,‖ but a short account of my specimens will not be out of place. Megascopically the predominant dark variety is black and aphanitic, with some scattered minute phenocrysts of diopside. The lighter kind, which occurs in less quantity, is rather pale gray, also dense, and shows small, yellowish phenocrysts of diopside and olivine. It has the appearance of being a bleached facies of the darker kind, but the results of the analyses do not bear out this supposition.

In thin section little difference is observable between the two varieties. They are both basaltic in structure, and show crystals and fragments of pale green or colorless diopside, some labradorite, and rare crystals and fragments of olivine, lying in a groundmass of diopside grains, labradorite laths, magnetite and apatite, with some leptomorphic orthoclase (?), and interstitial, brown globulitic glass.

An analysis was made of specimens of each variety, and the results are given in I and II. They are not entirely satisfactory, both summing up too high, and there seems to be a small constant error, which I am not able to place without duplicate analyses, for which time is lacking. They must, however, represent fairly well the composition of the rocks, and are interesting in being almost identical, so much so as to pass muster for duplicates. This was somewhat surprising in view of their quite different megascopic appearance, but the study of thin

* Hill and Vaughan, 18th Ann. Rep. U. S. G. S., p. 202 and pl. xxii, 1898.

† This summit scoria is largely used in the country round about for scraping the hair off of pig skins, and is hence rapidly disappearing.

‡ Vom Rath, Zeitschr. d. d. geol. Ges., xvii, p. 405, 1865.

§ Bucca, Boll. R. Com. Geol. Ital., 1887, p. 274.

‖ Mercalli, Atti Soc. Ital. Sci. Nat., xxx, 1887.

sections showed that it was to be expected. In their general features they resemble analyses of andesites, though possibly somewhat basic, and in this way approaching the basalts. It has been noted also that olivine is rare. The alkalies amount to somewhat more than five per cent, and K_2O molecularly is higher than Na_2O, though not as much so as in most other Italian rocks. The analyses do not differ radically from the older ones of vom Rath and Ricciardi, which are given for comparison. The large amount of SO_3 in Ricciardi's analyses is surprising, since no noselite could be found.

	I	II	III	IV	V
SiO_2	54·14	54·56	55·00	53·63	55·23
TiO_2	1·23	1·10	----	----	----
Al_2O_3	16·42	16·49	14·38	14·17	14·06
Fe_2O_3	1·69	1·02	----	1·46	5·06
FeO	5·26	5·65	9·29	8·07	4·12
MnO	trace	trace	----	trace	0·57
MgO	8·44	8·57	7·72	7·05	4·00
CaO	8·05	7·95	8 51	8·52	9·34
Na_2O	2·20	2·07	2·25	1·80	2·07
K_2O	3·34	3·35	2·52	2·03	2·43
H_2O	0·56	0·15	0·48	2·01	1·07
P_2O_5	----	----	----	0·93	1·33
SO_3	----	----	----	0·62	0·84
	101·33	100·91	100·15	100·29	100·12

I. Andesite (black), near Castle Gate, Radicofani. Washington anal.
II. Andesite (gray), west of village, Radicofani. Washington anal.
III. Andesite (gray), Radicofani, vom Rath, Zeit. deut. Geol. Ges., xvii, p. 405, 1865.
IV. Andesite (black), Radicofani. Ricciardi anal. Mercalli, Atti Soc. Ital. Sc. Nat., xxx, p. 4, 1887.
V. Andesite (gray), Radicofani. Ricciardi anal. Mercalli, op. cit., p. 8.

I previously* expressed the opinion that these rocks were probably ciminites, but the examination and analysis of the specimens collected since then, the results of which have just been given, show that while they are analogous to them in certain particulars, yet that they should properly be classed with the andesites, which, as well as the basalts, are rarely found on the Italian peninsula. The occurrence is of interest as showing that the Italian latites may shade off into true andesites and basalts, as well as into basic leucitic rocks.

* Jour. Geol., v, p. 355, 1897.

Leucitite, Capo di Bove, Alban Hills.—Of the well-known rocks of the Alban Hills only the analyses made by Bunsen in 1861 have been published.* It was, therefore, thought advisable to make a new analysis of one of these rocks, and for this purpose a fresh specimen collected at the quarries at Capo di Bove, near the tomb of Cecilia Metella, was selected. The rock, a flow from the Alban volcano, is the well known one which is found in all collections, and does not call for a lengthy description. It need only be said that this specimen is composed of leucite, melilite, nephelite, diopside, magnetite, a few flakes of biotite, scarcely any apatite, and no glass.

	I	II	III
SiO_2	45·99	45·93	46·51
TiO_2	0·37	----	0·83
Al_2O_3	17·12	18·72	11·86
Fe_2O_3	4·17	----	7·59
FeO	5·38	10·68	4·39
MnO	trace	----	0·22
MgO	5·30	5·67	4·73
CaO	10·47	10·57	7·41
BaO	0·25	----	0·50
SrO	none	----	0·16
Na_2O	2·18	1·68	2·39
K_2O	8·97	6·83	8·71
H_2O (110°) −	0·45	0·59	1·10
H_2O (110°) +			2·45
	100·65	100·67	99·73†

I. Leucitite, Capo di Bove. Washington analyst.
II. Leucitite, Capo di Bove. Bunsen analyst. Roth. Beitr. Petr., 1869, p. cii, No. 31.
III. Leucitite, Bearpaw Mountain, Montana. H. N. Stokes anal. Weed and Pirsson, this Journal, ii, p. 147, 1896.

The analysis, which resembles closely the older one of Bunsen (II), except as to Al_2O_3 and K_2O, is characterized by high K_2O, CaO and iron oxides, and, for so basic a rock, quite high Al_2O_3 and low MgO. It was thought possible that the same error had been made in the determination of these two oxides which has already been noticed elsewhere. So a second analysis was made recently, which, however, gave results quite confirmatory of those of the earlier one. The figures given above are the means of the two closely agreeing determinations of all the constituents, except H_2O. They may, therefore, be considered reliable.

* Roth. Beitr. Petr. plut. Gest., 1869, p. cii, Nos. 30–33.
† Including 0·80 P_2O_5, 0·04 Cl, 0·04 NiO and traces of CuO, CoO, F and SO_3.

The apparently high Al_2O_3 is largely taken up by the abundant leucite, while the melilite and especially the nephelite also demand quite an amount of it. Owing to the composition of the melilite and diopside a calculation of the mineral composition of the rock is not easy or satisfactory. Assuming, however, that by far the greater part of the K_2O and Na_2O belongs in the leucite and nephelite, it is calculated that leucite makes up about 52 and nephelite about 10 per cent, leaving some 38 per cent of melilite, diopside and magnetite. It is difficult to say exactly how these are distributed, but a rough estimate, combined with the microscopical examination, gives melilite and diopside each about 17 per cent and magnetite about 5 or less.

In the leucitite of Bearpaw Mountain, Montana (III), described by Pirsson,* MgO is also low, though Al_2O_3 is considerably lower than in the Alban rock. The Montana rock, however, is composed only of leucite (57·1 per cent), diopside (31·1 per cent) and magnetite (11·8 per cent), and contains neither nephelite nor melilite.

Comparison of these analyses with that of venanzite given on a preceding page is of interest. The lower SiO_2 and Al_2O_3 and higher MgO in this latter have conditioned the abundant olivine and considerable biotite, both of which are wholly absent in the leucitite. The nepheline of the latter at the Alban Hills is, conversely, lacking in the venanzite.

In this connection I would express my complete agreement with Dr. Cross† in his suggestion that "the term leucitite be reserved for the rock which has not yet been discovered, consisting essentially of leucite, with all other minerals of subordinate importance. There is good reason to believe that such rocks are possible and will be found at no distant day. The same suggestion is made for nephelinite, on the same grounds."

Following out this idea it is evident from the above estiment of the mineralogical composition of the Capo di Bove rock, however crude it may be, that the term leucitite is not quite appropriate. The same would hold true of the term as applied to any of the Italian or other leucitites so far as known. The present is not the place for any discussion, nor for the bestowal of new names, but the fact is obvious that a critical revision and reclassification of all the leucitic rocks is highly desirable.

Locust, N. J., November, 1899.

* Weed and Pirsson, this Journal, ii, p. 143, 1896.
† Cross, this Journal, iv, p. 137, 1897.

ART. VII.—*The Constitution of the Ammonium Magnesium Arseniate of Analysis;* by MARTHA AUSTIN.

[Contributions from the Kent Chemical Laboratory of Yale University—XCII]

THE striking analogy between the phosphates and the arseniates led Levol* to undertake the separation of an ammonium arseniate corresponding to the ammonium magnesium phosphate, the composition of which Berzelius had given. Levol states that ammonium magnesium arseniate of the composition $NH_4MgAsO_4.10H_2O$ is obtained by adding a solution of a double ammonium magnesium salt to arsenic acid, and that it is a salt possessing about the same degree of solubility in water, in ammoniacal water, and in ammoniacal water containing magnesium salt, as the corresponding phosphate. Further, he found that by heating this salt to red heat after carefully drying, magnesium pyroarseniate was given, from which arsenic can be estimated readily.

Wach† and H. Rose‡ obtained the ammonium magnesium arseniate containing six molecules of water of crystallization by precipitating arsenic acid with magnesia mixture and then adding an excess of ammonia, and by drying at 100° C. were able to estimate the arsenic present as the ammonio-magnesium arseniate containing one-half molecule of water. This method seemed to offer an advantage over the method of estimation as the pyroarseniate, for results obtained below the theoretical amount of arsenic present gave rise to the suspicion that during ignition arsenic was reduced by the ammonia driven off. Rose attempted in another way to avoid this loss by igniting in a current of oxygen; and later Reichel‡ ignited the residue after carefully saturating it with ammonium nitrate and nitric acid, and drying at 100° C. Rammelsberg§ believed that it was safer to ignite after drying at 120° C. because drying at 100–110° C. caused a loss of ammonia before ignition. Kaiser¶ dried the residue in a current of air.

A second source of error discussed by H. Rose,** Fresenius and others is due to the solubility of the ammonium magnesium arseniate in water, in ammoniacal water, and ammoniacal water containing magnesium salts. Wood†† attempted to avoid this by precipitating the ammonio-magnesium arseniate with an alcoholic magnesia mixture, and by washing the precipitate with an alcoholic solution, by weighing the residue

* Ann. de Chim. et de Phys., III, xvii, 501, 1846.
† Schweigger, Journ. f. Ch. u. Phys., lix, 297. ‡ Ann. d. Phys, lxxvi, 20.
§ Ber. d. d. Chem. Gesell., xiv, 279. ‖ Ber. d. d. Chem Gesell, vii, 544.
¶ Zeitschr. f. Anal. Chem., xiv, 250. ** Zeitschr. f. Anal. Chem., iii, 206.
†† This Journal, III, vi, 368.

ignited in a crucible held in a second protecting crucible, after treating with nitric acid and ammonium nitrate, he obtained concordant results. Brauner* followed this method with success.

As has been shown by Dr. Hugo Neubauer,† ammonium chloride tends to form a phosphate of magnesium too rich in ammonia, and in papers‡ from this laboratory it has been shown that the tendency of ammonia and ammonium chloride is to cause the replacement of some of the metal in the ammonium phosphate of manganese, of magnesium and of other metals in the second group of Mendeléeff, giving phosphates too rich in ammonia for the ideal constitution. The marked similarity as to behavior between the phosphates and the arseniates led to the investigation of the constitution of the ammonium magnesium arseniate under the usual conditions imposed in analysis, and, further, to the effect of ammonium chloride on the salt of ideal constitution.

In the table which follows are recorded a set of qualitative tests, in which the hot filtrates were tested by hydrogen sulphide in presence of hydrochloric acid. These tests were made to show under what conditions of volume, given amounts of arsenic acid can be entirely removed by magnesia mixture from ammoniacal solutions alone, or from ammoniacal solutions containing ammonium chloride. The ammonium chloride for this work was carefully purified by heating it to boiling temperature in concentrated solution — 1 grm. to 3^{cm^3} — with ammonia in slight excess. The magnesia mixture was prepared by dissolving one hundred and ten grams of the crystallized magnesium chloride in a small volume of water, filtering and adding to it fifty-eight grams of ammonium chloride in solution, purified by adding bromine water and bleaching with ammonia, filtering and then diluting to a volume of two liters, adding enough ammonia—10^{cc}—to make this solution smell distinctly of ammonia.

The results (1) to (3) recorded in the table were obtained by precipitating the arsenic present in solution by means of the magnesia mixture prepared as described and rendering the solution distinctly ammoniacal. After standing until the precipitate subsided, the solution was filtered and tested for arsenic by hydrogen sulphide. Within certain limits of volume all the arsenic is removed from solution by the magnesia mixture. In case of (3) two additional amounts of the precipitant had to be made in order to remove the arsenic, the

* Zeitschr. f. Anal. Chem., xvi, 57.

† Zeitschr. f. Anorg. Chem., ii, 45; iv, 251; x, 60. Zeitschr. f. Angen Chem., 1896, 435. Jour. Amer. Chem. Soc., xiv, 289.

‡ This Journal, vi, 233; vii, 187; viii, 206.

solution being ammoniacal. Results (4) to (10) of the table were obtained in the same manner as (1) to (3), the amount of arsenic acid present being increased ten times. In (9) and (10), where the smaller amounts of magnesia mixture were used,

TABLE I.

	Volume. cc.	Arsenic present in terms of As_2O_5. grm.	Magnesia mixture. cc.	NH_4OH. cc.	NH_4Cl. grm.	Indications of arsenic in the filtrate by H_2S.
(1)	100	·05	20	slight excess	--	none
(2)	200	·05	20	" "	--	"
(3)	300	·05	I 20	" "	--	I present
			II 20			II present
			III 20			III none
(4)	200	·5	50	" "	--	none
(5)	300	·5	50	" "	--	present
(6)	300	·5	50	2	--	"
(7)	200	·5	50	4	--	"
(8)	200	·5	30	2	--	present
(9)	200	·5	I 30	4	--	I present
			II 10			II none
(10)	100	·5	I 30	2	--	I present
			II 10			II none
(11)	130	·5	50	excess	10	present
(12)	200	·5	50	"	10	"
(13)	150	·5	75	"	10	none
(14)	250	·5	75	"	10	present
(15)	300	·5	75	2	10	trace
(16)	400	·5	75	2	10	present
(17)	285	·5	100	excess	10	none
(18)	215	·5	100	"	20	none
(19)	335	·5	100	"	60	present
(20)	360	·5	125	"	60	present
(21)	360	·5	150	"	60	none

additional portions had to be added before all the arsenic was removed from solution. When the larger amounts of ammonia were used the results did not seem to be influenced, (7) and (9). The results recorded in (11) to (21) were obtained by precipitating the arsenic in solution in presence of ammonium chloride by the magnesia mixture. It is evident that the presence of ammonium chloride causes some arsenic to be dissolved and further that this solvent effect is overcome by the magnesia mixture added in larger amounts, even when the ammonium chloride present amounts to sixty grams in weight, as in (21).

In order to find how much arsenic is dissolved from the ammonium magnesium arseniate once precipitated so that no arsenic is left in solution, experiments were made in which the arsenic in the filtrate was weighed after precipitating by hydrogen sulphide in hot acid solution, filtering off on asbestos under pressure, washing successively with water, alcohol, carbon disulphide, alcohol, and water, and drying at 100° C.

TABLE II.

H_2O containing 1^{cc} NH_4OH in 200^{cc}. grm.	NH_4OH S. G. 0·96. cc.	As_2O_5 digested. grm.	As_2O_5 found as As_2S_3. grm.
---	100	0·5	0·0019
---	100	0·5	0·0026
100		0·5	0·0003
100		0·5	0·0005
10		0·5	0·0002
10		0·5	0·0004

It is evident from these qualitative tests that, so far as concerns the amount of arsenic dissolved from the ammonium magnesium arseniate, it is safe to use a faintly ammoniacal washwater in small amounts—less than 100^{cc}—to remove traces of reagents from the residue after it is gathered upon the asbestos felt. Usually 25–50^{cc} of washwater were used in rinsing off the precipitate in the experiments about to be given below.

The solution of arsenic employed in this work was prepared by dissolving ten grams of pure arsenious oxide, carefully resublimed, in a platinum dish in an excess of pure nitric acid and evaporating on the waterbath to dryness, dissolving the arsenic acid produced in water and diluting to a volume of one liter in a standard flask.

Definite portions of this solution were drawn from a burette into a platinum dish and precipitated with magnesia mixture prepared as described in the proportion shown necessary by the qualitative tests for the complete removal of the arsenic from solution, and the solution was made distinctly ammoniacal. The precipitate, dissolved in hydrochloric acid in slight excess, was brought down again by ammonia in distinct excess. After standing until the precipitate had completely subsided, the precipitate was gathered on an asbestos felt in a perforated platinum crucible, making use of the filtrate to remove the last portions of the precipitate to the felt, before washing any reagents from it on the felt with faintly ammoniacal water. After carefully drying, the residue was ignited to the pyroarseniate. The results shown in A fall so far below the theory for magnesium arseniate that it seems evident that the arseniate

shows a tendency here to form a salt richer in ammonia than the ideal $MgNH_4AsO_4$, and yielding on ignition some meta-arseniate instead of the normal pyroarseniate. In section B the magnesium ammonium arseniate was precipitated by adding to the solution of arsenic acid magnesia mixture containing no free ammonia in the proportion necessary (50^{cm^3}) to remove the arsenic from solution, and then making the solution distinctly ammoniacal. After the precipitate had subsided, it was filtered off on asbestos under pressure in a perforated platinum crucible, washed on the felt with ammoniacal water, dried and ignited. These results are also below the theory for the pyro-arseniate. Evidently the conditions here are even better for the formation of the salt too rich in ammonia than they were in the first case. No arsenic was found by hydrogen sulphide in any case either in the filtrate or in the washwater after acidifying and heating.

TABLE III.

$Mg_2As_2O_7$ corresponding to As_2O_5.				As_2O_5 found by H_2S in the filtrate.
Taken. grm.	Found. grm.	Error. grm.		
			A	
0·7843	0·7800	0·0043 —		none
0·7843	0·7794	0·0049 —		none
			B	
0·7843	0·7772	0·0071 —		none
0·7843	0·7769	0·0074 —		none

In section A of Table IV the results recorded were obtained by precipitating definite portions of arsenic acid drawn from a burette into a platinum dish with the distinctly ammoniacal magnesia mixture in proper proportion, and afterward adding a little more ammonia, filtering off on asbestos under pressure in a perforated platinum crucible as soon as the precipitate subsided, washing off on the felt with ammoniacal water any of the reagents left on the precipitate in transferring it to the felt by using the filtrate, drying and igniting. No arsenic was found in any case in the filtrate or in the washwater by hydrogen sulphide. The conditions of precipitation here prove to be such, as the results show, that the salt of ideal constitution is formed. Comparing these results with those of Table III, it seems that the conditions under which the salt of ideal composition is formed are such that at the moment and in the locality of precipitation the amount of magnesium chloride in a certain volume of solution must be large in proportion to the amount of ammonia present as the chloride and the hydroxide; otherwise the ammonium of the ammonium arseniate, naturally formed first, does not suffer sufficient displacement by magnesium to produce the normal ammonium magnesium arseniate.

At all events, the treatment applied in the experiments of A resulted practically in the complete precipitation and in the production of a precipitate of nearly ideal constitution.

TABLE IV.

	$Mg_2As_2O_7$ corresponding to As_2O_5. Taken. grm.	Found. grm.	Error. grm.		Magnesia mixture. cc.	NH_4Cl. grm.
				A		
(1)	0·7843	0·7830	0·0013—		50	--
(2)	0·7843	0·7849	0·0006—		50	--
(3)	0·7843	0·7841	0·0002—		50	--
(4)	0·7843	0·7843	0·0000—		50	--
				B		
(5)	0·7843	0·7763	0·0080—		75	10
(6)	0·7843	0·7762	0·0081—		75	10
(7)	0·7843	0·7832	0·0011—		100	10
(8)	0·7843	0·7838	0·0005—		100	10
(9)	0·7843	0·7784	0·0059—		100	20
(10)	0·7843	0·7810	0·0033—		100	20
(11)	0·7843	0·7849	0·0006+		150	60
(12)	0·7843	0·7846	0·0003+		150	60

In section B of the same table the results recorded show the effect of increased amounts of ammonium chloride on the constitution of the ammonium magnesium arseniate. Enough magnesia mixture was used in each case to remove the arsenic completely from solution. The precipitates were gathered on asbestos in a perforated platinum crucible and treated as those described in section A of the table. It is evident as shown by (5) and (6) of the table that ammonium chloride causes a replacement of some of the metal by ammonia in the ammonium magnesium arseniate (to form, possibly, a salt of the constitution $Mg(NH_4)_4AsO_4$) though the solvent effect of the ammonium chloride is overcome by the addition of a sufficient amount of magnesia mixture. No arsenic appeared in the filtrates, and, further, experiments (7) and (8) show that increasing the amount of magnesia mixture present will cause the formation of the salt of ideal constitution even in presence of considerable amounts of ammonium chloride. Indeed this is possible where as large an amount as sixty grams of the salt is present, as results (11) and (12) show. Obviously, ammonium chloride in any amount above what is required for the magnesia mixture tends to dissolve the precipitate, but this solvent effect may be neutralized by increasing the amounts of magnesia mixture even though the precipitate formed is richer in ammonia than the ideal salt.

In no one of the many precipitates tested by silver nitrate for included chlorides was more than an inappreciable trace found.

Evidently, when ammoniacal magnesia mixture, amounting to about thirty cubic centimeters in excess of the theoretical amount necessary to precipitate all the arsenic as the ammonium magnesium arseniate, is added to the faintly acid solution of arsenic acid (carrying no ammonium salts) in a volume not exceeding two hundred cubic centimeters, the precipitate appears to fall in ideal condition. If the precipitated salt is transferred to the filtering crucible by the aid of portions of the filtrate used as the washing liquid and finally washed on the asbestos with about twenty-five cubic centimeters of faintly ammoniacal water—an amount which is quite sufficient after the transfer has been made—no arsenic gets into solution. The weight of the carefully dried and ignited pyroarseniate indicates with accuracy the amount of arsenic present.

I wish here to thank Professor F. A. Gooch for the help and advice he has constantly given throughout this work.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Use of the Method of Limiting Density in recalculating Atomic masses.*—It has been shown by D. Berthelot that the molecular masses of gases are proportional to their densities at infinitely small pressures and hence that they may be calculated from data derived from compression. Results thus obtained for the atomic masses of hydrogen, nitrogen and carbon, as calculated from the limiting density of their oxides, are in good agreement with those obtained by chemical methods. More recent results give for carbon 12·0025 from acetylene, 12·000 from carbon dioxide and 12·007 from carbon monoxide; the most probable value being 12·005. For nitrogen 14·000 from nitrous oxide, the probable value being 14·005. For argon, from Rayleigh's values, molecular mass 39·882. For chlorine 35·479 from hydrogen chloride, identical with Stas's value if 107·912 be accepted for silver. For sulphur, 32·046 from sulphur dioxide, Stas's result being 32·045. It would appear, therefore, that the physical method as devised by the author is capable of great accuracy.—*C. R.*, cxxvi, 1501–1504, 1898. G. F. B.

2. *On the Newly Discovered gases and their Relation to the Periodic Law.*—A lecture on the new gases of the atmosphere has been delivered by Ramsay before the German Chemical Society. Deeming it possible that a group of elements may exist between the nitrogen group and the lithium group of the periodic system, such as He = 4, ? = 20, A = 40, the author examined 15 liters of argon, liquefied in a Dewar's tube by means of boiling liquid air, and giving 25^{cc} of a clear liquid having some solid flakes floating in it. On allowing the pressure on the boiling air to rise, the argon boiled off, the least volatile part being collected apart. This he calls *metargon*, though it has not been obtained free from argon, and has been but little studied. The first most volatile fraction, on cooling in liquid air, only partially liquefied. The remaining gas contained a new constituent which he called *neon*, though it was mixed with helium and argon. Purified as far as possible it had a density of 10·19, and a refractive power of 0·388. Its spectrum gave lines in the red of wave length 6402, 6383, 6335, 6227, 6218, 6164, 6143, 6096, 6074, 6030; yellow (D_5) 5853; green 5401, 5341, 5331; blue 4716, 4722, 4710, 4709, 4704. If 1·67 is the ratio of its specific heats, its atomic mass is 20, corresponding to the missing element of the above group. On collecting separately the last portions of gas from the liquid air used for liquefying the argon, it was found to have a density of 22·5, a specific heat ratio of 1·66, and to give spectrum lines in the red, yellow and green (5570). This gas he called *krypton.* Still another gas, accompanying argon in air, obtained, however,

only in an impure state, had a density of 32·5 and was called *xenon*. It could not be detected in the 15 liters of argon, but only in the large quantities of liquid air used. It has several lines in its spectrum but none are brilliant.—*Ber. Berl. Chem. Ges.*, xxxi, 3111–3121, Dec., 1898. G. F. B.

3. *On the Preparation of Calcium and Calcium hydride.*—By the electrolysis of anhydrous calcium chloride in a graphite crucible containing a porous cell von Lengyel has obtained metallic calcium. The positive electrode was placed in the crucible and the negative in the porous cup, a current of 10–18 amperes under a pressure of 70–110 volts being employed. On placing the regulus obtained in anhydrous ether a product is obtained containing 99·2 per cent of calcium. The metal has a density of 1·5540 at 18°, resembles in color a gold alloy rich in silver, is not affected by cold dry air, but burns brilliantly at a red heat. It unites at ordinary temperatures with hydrogen to form the hydride CaH_2, the action being very energetic at a red heat. This hydride is a grayish earthy substance which decomposes water even more readily than the metal, the hydrogen often inflaming, and burns brilliantly in oxygen at a red heat.—*Chem. Centralbl.*, ii, 262, 1898. *J. Chem. Soc.*, lxxvi, ii, 218, April, 1899. G. F. B.

4. *On Non-explosive Decomposition.*—It has been pointed out by Hoitsema that rapid and slow decompositions in some cases yield products which are identical, while in others the reverse obtains. Since gun-cotton belongs to the latter class of substances, no explosion-velocity experiments are possible. At about 150° it can be slowly decomposed without explosion, evolving gases containing a little N_2O_4 and leaving a non-explosive peat-like mass containing about 7 per cent of nitrogen. Higher nitrogen oxides do not appear to result from secondary reactions, since it is easy to prove by special apparatus that they precede the formation of nitric oxide. It would seem, therefore, that these higher oxides are due to impurity, or are produced only in the initial stages of the reaction. Ordinarily the stability of a gun cotton is determined by observing the time elapsing before nitric fumes are evolved at a fixed temperature. In the author's apparatus the explosive may be maintained at any desired temperature for any length of time. Hence he thinks it better to ascertain the highest temperature at which the sample may be kept for a quarter of an hour or so without emitting nitrous fumes.—*Zeitschr. physikal. Chem.*, xxvii, 567–578, Dec., 1898. G. F. B.

5. *On Crystalline Liquids.*—It is well known that two views are held on the subject of crystalline liquids; the one by Lehmann who regards them as crystals of remarkably small viscosity, the other by Quincke who maintains that they consist of a multitude of minute solid crystallites each enclosed in a thin liquid film. Schenck has pointed out that if the latter supposition be true, the liquid crystals not being homogeneous, then different transition temperatures ought to be found for different preparations and for the products crystallized from different solvents. To test

the matter he crystallized parazoxyanisoil from (*a*) acetone, (*b*) alcohol and (*c*) chloroform. As he was unable to detect any appreciable change of the transition-point, he concludes that the view of Lehmann is the more probably correct. It has been pointed out by Ostwald that the stability-interval of crystalline liquids must be near the critical point for solid and liquid; i. e., near the temperature at which the heat of fusion is zero. By means of the specific heats of the crystalline and the isotropic liquids, the difference between the transition and critical temperatures is calculated as (1) 27·6° and (2) 18·4°. The difference in these values may perhaps be due to dimorphism of the compound. Hence the author considers desirable further determinations with other compounds.—*Zeitschr. physikal. Chem.*, xxviii, 280–288, March, 1899. G. F. B.

6. *On the Density of Liquid Air, and of other liquefied Gases.*—Experiments have been made by LADENBURG and KRÜGEL to determine the density of liquefied air and other gases. For this purpose they made use of glass rods, whose density had been carefully determined by weighing in air and in water at 4°. By means of a Mohr's balance these rods were carefully weighed in the liquefied gases, the decrease in weight being accurately noted. No correction was made for the buoyancy of the atmosphere, and none for the contraction in volume of the glass, as its coefficient for these low temperatures was not known. In the case of liquid air the authors determined simultaneously its composition. They found (1) that freshly liquefied air had a density of 0·9951, and contained 58·83 per cent of oxygen. (2) That after several hours, the density increased to 1·029, when it contained 64·2 per cent of oxygen. (3) That after standing for 2 or 3 days until most of the nitrogen had evaporated, the density rose to 1·112, there being present in it 93·6 per cent of oxygen. The authors, therefore, conclude that the density of a liquid containing 20·9 per cent of oxygen would be 0·87–0·90. Liquid oxygen pure has a density slightly lower than the above mentioned mixture containing 93·6 per cent of it, being 1·105–1·108. The fusing point of ethylene was found to be $-169°$ and the boiling point $-105·4°$ at 760^{mm} pressure; the values given by Olszewski being the same for the fusing point but $-102·5°$ for the boiling point. The density of the liquid at $-169°$ was noted as 0·6585 and at $-105·4°$, 0·571.—*Ber. Berl. Chem. Ges.*, xxxii, 46–49, 1899. G. F. B.

7. *Leçons de Chemie Physique*, professées à l'Université de Berlin. Par J. H. VAN'T HOFF, Professor ordinaire à l'Université. Traduit de l'allemand par M. Corvisy. Deuxième Partie. La Statique Chimique. 8vo, pp. 162. Paris, 1899 (Hermann).—This is the second part of Professor Van't Hoff's Berlin lectures, the first part having been noticed in this Journal for February, 1899, p. 157. G. F. B.

8. *Lehrbuch der Allgemeinen Chemie;* von Dr. WILH. OSTWALD. Zweite umgearbeitete Auflage in zwei Bänden. Zweiten Bandes Zweiter Teil. Verwandtschaftslehre, Vierte Lieferung,

Bogen 39–52 mit figur 71–152. Leipzig, 1899 (Engelmann).—An additional part of this most valuable treatise of Ostwald on General Chemistry. G. F. B.

9. *Grundriss der Allgemeinen Chemie;* von W. Ostwald. Dritte umgearbeitete Auflage. 8vo. pp. xvi, 549. Leipzig, 1899 (Engelmann).—This excellent abridgment of Professor Ostwald's larger work has proved so useful to the chemical student that a third edition will be warmly welcomed. The revision has been thorough and considerable new matter has been added. G. F. B.

10. *Laboratory Manual.* Experiments to illustrate the Elementary Principles of Chemistry; by H. W. Hillyer, Ph.D. 8vo, pp. vi, 200. New York, 1899 (The Macmillan Co.).—This book is designed for the use of college students in general chemistry, the odd pages being left blank for notes. Part I comprises the preparation and properties of the elements and their compounds, and Part II, the verification of quantitative laws. It seems to have been carefully compiled. G. F. B.

11. *Strahlung und Temperatur der Sonne;* von Dr. J. Scheiner, Professor der Astrophysik an der Universität Berlin. 8vo, pp. iv, 99. Leipzig, 1899 (Engelmann).—A valuable contribution to the solar radiation question, giving the latest results of the best observers. In an appendix the diameter of the sun is discussed. G. F. B.

12. *Influence of small impurities on the spectrum of a gas.*—The difficulties in obtaining pure gases for spectrum analysis are well known to physicists. These gases are necessarily contained in glass tubes or receptacles: and the varying quality and conditions of the glass affect the conditions of the gases, especially when powerful electrical discharges are employed. The preparation of X-ray tubes has brought out forcibly the necessity of heating the glass receptacles repeatedly, and also subjecting them to electrical discharges in order to drive off the adhering layers of air. It is probable that one never succeeds in freeing the glass entirely from aqueous vapor. Indeed grave doubts exist whether many of the spectral lines attributed to a gas—for instance, hydrogen—are really lines of the pure gas. Mr. P. Lewis has investigated the influence on the spectrum of hydrogen and other gases of small impurities. The gases were in electrodeless tubes, in order to avoid the questions of the absorption of the gases by metals. He found that a small quantity of oxygen in hydrogen increased the brilliancy of the hydrogen spectrum—the mercury vapor spectrum appeared to strongly diminish the brilliancy of the hydrogen spectrum. Mr. Lewis is of the opinion that the mixed spectrum of hydrogen—the white spectrum and the characteristic line spectrum which appears strongly when a Leyden jar is used—is a real hydrogen spectrum. In electrodeless tubes the hydrogen spectrum is brightest at about 3^{mm} pressure; and in electrode tubes at $0{\cdot}6^{mm}$. In a pure oxygen atmosphere the spectrum of mercury vapor arising from the pump was not present; a small trace of hydrogen brought out the green

line of hydrogen. The influence of mercury at very low temperatures was also investigated. The paper is a valuable contribution to spectrum analysis.—*Wied. Ann.*, No. 10, 1899, pp. 398–425. J. T.

13. *On the limit of hearing.*—RUDOLPH KOENIG in an opening article discusses this question, whether the upper limits set by various authors, c^6 to c^7 or c^8, is a true one. On account of the psychological questions involved in taking what may be called hearsay evidence—of observers—Koenig resolved to study the subject by means of Kundt's dust figures. The paper contains numerous plates of the results obtained, which are remarkable from an experimental point of view, and the author promises a continuation of his paper.—*Wied. Ann.*, No. 11, 1899, pp. 626–660. J. T.

14. *Rotating bodies in electric fields.*—A. HEYDWEILLER in a long paper discusses the phenomena of the solution of bodies in electric fields of greater and of less conductivity than the bodies. He agrees with certain other investigators in finding evidence of accelerating or retarding forces, due to changes in the electric fields. His investigations lead him to determination of the electrical conductivity of air at different pressures, and he discusses the probable effect of these accelerating or retarding forces on the motion of the sun and planets. It appears to him that the motion of the moon may be appreciably affected by these electrical forces.—*Wied. Ann.*, No. 11, 1899, pp. 531–575. J. T.

15. *Masses of ions in gases at low pressures.*—A very important paper was presented at the late meeting of the British Association at Dover on this subject by Prof. J. J. THOMSON and a fuller account is now published in the Philosophical Magazine. It is believed by the author that the composition of a gas consists in the detachment from the atom of a negative ion; this negative ion being the same for all gases, while the mass of the ion is only a small portion of the mass of an atom of hydrogen. This negative ion, therefore, becomes of the utmost importance in all theories of electrical action, and may be the fundamental quantity in terms of which all electrical process can be expressed. The mass of an atom is not invariable. Electrification of a gas consists in splitting up some of the atoms of a gas. The detached corpuscles act like negative ions; each carrying a constant negative charge, which the author calls the unit charge.

This theory is carefully elaborated and forms the most important contribution to this subject of the present year.—*Phil. Mag.*, Dec. 1899, pp. 547–567. J. T.

II. Geology and Mineralogy.

1. *Coal Deposits of Indiana;* by W. S. Blatchley, State Geologist, pp. 1–1741, Coal maps, A–G, Plates i–xciii, figures 1–986:—Indiana, Department of Geology and natural resources, 23d Annual Report, 1898.—This bulky volume is made up chiefly of a detailed report on the Coal deposits of Indiana (pp. 1–1573). The statistics for this have been gathering during the years 1896–1898, by Dr. Geo. H. Ashley and his assistants, adding greatly to the facts available when the last report on the Coal area was published in 1878. Following this is the Report of the State Inspector of Mines, by Mr. Robert Fisher (pp. 1574–1674). Seventeen counties are stated to be coal-producing, with a total out-put of over five million tons in 1898; an increase of 948–958 tons over the production for 1897. This increase in coal mining is traced to the gradual decrease in gas flow in the state. The closing part is the Annual Report of the Natural Gas Supervisor (pp. 1675–1702), by J. S. Leach, The natural gas is fast being exhausted; the pressure, which was at first 325 pounds to the square inch, is now less than 200 lbs. The following summary of the present condition of the Indiana natural gas field is given:

"1. The gas resources of the territory in the gas field is practically all controlled by territory under lease, either by gas companies or manufacturers, and the pipe line companies, which are the large consumers of natural gas, have extended their lines from year to year and are apparently centering around Fairmount township, Grant county.

"2. The undeveloped territory in the field, that not invaded by pipe lines and having only sufficient wells to supply local consumption, comprises about 150 square miles in Grant, Madison and Delaware counties. Possibly a few square miles in Licking township, Blackford county, should be added to this.

"3. If the yearly extension of pipe lines is as great in the future as it has been in the past, it will not require to exceed two years to completely occupy this territory. It does not follow from what has been said that the natural gas field will be exhausted in two years; for after the field is threatened with pipe lines doubtless many wells will be drilled with results that will justify the expense.

"4. The salt water, that has been a menace to the natural gas interests from the beginning, is becoming more intrusive day by day, there being but few wells in the field entirely free from its influence. Wells apparently free from it when drilled become wet soon after being attached to the line.

"5. Rock pressure does not indicate the productiveness of one well as compared with another, but any material decline of the same indicates a diminution in the supply. The average rock pressure of the undeveloped territory in 1895 was 264 pounds. The average of the same territory at present is 181 pounds, a

decrease of 83 pounds in a little more than three years. The average rock pressure of the entire gas-producing territory, November, 1897, was 191 pounds; November, 1898, the average of the same territory was 173, a decrease of 18 pounds.

"6. The history of other gas fields, the past history of this and all its present conditions, justify the statement that the supply of gas is failing and will finally be exhausted." (pp. 1688-9.)

W.

2. *Geological Survey of Canada*, G. M. DAWSON, Director.—The following Reports and Map-Sheets have been recently published:

Annual Report, Vol. X, No. 678. Report on the Geology of the area covered by the Seine River and Lake Shebandowan Map-Sheets, comprising portions of Rainy River and Thunder Bay Districts, Ontario, by William McInnes, pp. 5 H–65 H, plates I–III, 1899.

Maps to accompany Part H, Vol. X (New Series): 560. Seine River Sheet, Thunder Bay and Rainy River Districts, Ontario. 589. Lake Shebandowan Sheet, Thunder Bay District, Ontario.

Annual Report, Vol. X, No. 672. Report on the Geology and Natural Resources of the area included by the Nipissing and Temiscaming Map-Sheets, comprising portions of the District of Nipissing, Ontario, and of the County of Pontiac, Quebec, by Alfred Ernest Barlow, pp. 5 I–302 I, plates I–V, figures 1–4, 1899.

Maps to accompany Part I, Vol. X (New Series): 599. Lake Temiscaming Sheet, Nipissing District, Ontario, and Pontiac Co., Quebec. 606. Lake Nipissing Sheet, Nipissing District, Ontario, and Pontiac Co., Quebec.

Annual Report, Vol. X, No. 662. Section of Mineral Statistics and Mines, Annual Report for 1897, by Elfric Drew Ingall; Assistants, Theo. C. Denis, J. McLeish, pp. 5 S–232 S, geol. map, 1899.

No. 669. Shuswap Sheet (British Columbia). Economic minerals and glacial striæ, by G. M. Dawson, assisted by J. McEvoy, 1898, scale $\frac{1}{253.440}$.

No. 604. Shuswap Sheet, geologically colored. In this sheet the following formations are recognized and defined, viz.:

Upper Volcanic Group (chiefly basalts), Tranquille Beds, etc.,	Miocene.
Coldwater Group,	Oligocene.
Nicola Formation,	Triassic.
Cache Creek Formation, (Marble Canon Limestones ?) Cache Creek Formation, (lower members)	Carboniferous.
Adams Lake Series, Nisconlith Series,	Cambrian.
Shuswap Series, (and foliated granites.)	Archæan.

W.

3. *Dictyospongidæ—A Memoir on the Palæozoic Reticulate Sponges constituting the family Dictyospongidæ;* by JAMES HALL, in collaboration with JOHN M. CLARKE, University of the State of New York, State Museum, Memoir II, pp. 1–350, plates I–LXX, figures 1–45.—This exhaustive monograph on the Paleozoic fossil sponges was begun in the '80's. Professor Hall's first description of nine species of Dictyophyton, in 1863, referred them to the Algæ. In 1881,* Whitfield recognized their spongeous nature; and in 1882, an advanced notice of, and in 1884, a number of plates and descriptive text of a report with nearly the same title as the present volume, were issued by Hall in the Thirty-fifth Annual Report of the State Museum of New York. The 128 species are distributed in seven sub-families, under thirty-two genera. One genus is reported from the Lower Helderberg. The latest species are from the Keokuk group, and the largest number of species and genera are from the Chemung (82 species in 16 genera). The plates are exquisite examples of the lithographer's work. W.

4. *Geological Survey of Alabama.*—A map of the Warrior Coal Basin with columnar section of formation so far as it carries workable coals, prepared by HENRY MCCALLEY (on a scale of 7 miles to 8^{cm}), is issued Nov. 1st by the State Geologist, Eugene A. Smith, anticipating the later printing of the Report. W.

5. *Studies on Cambrian Faunas.*—The following important papers by G. F. MATTHEW are printed in the Transactions of the Royal Society, Canada (1899–1900, vol. v, section iv, pp. 39–139, plates i–viii): No. 3. Upper Cambrian Fauna of Mount Stephen, British Columbia; The Trilobites and Worms. No. 4. Fragments of the Cambrian Faunas of Newfoundland; The Etcheminian Fauna of Smith Sound, Newfoundland, by G. F. Matthew. W.

6. *American Museum of Natural History.*—Catalogue of the types and figure specimens in the Palæontological collection of the Geological Department, American Museum of Natural History, by R. P. WHITFIELD, assisted by E. O. HOVEY, Part II, beginning with the Medina Sandstone, pp. 74–188, has recently been issued under date of Oct. 12, 1899.

7. *Bulletin of the Wisconsin Survey-Building and Ornamental Stones of Wisconsin;* by E. R. BUCKLEY, Ph.D., 8°, pp. 544, Pls. 69. Madison, 1898.—This volume begins with a general account of the demands, uses and properties of building and ornamental stones and then after a brief geological history of the state, the different areas and quarries are taken up and described separately with an account of the rocks which they yield. A number of very excellent and lifelike (if one may use such a term in reference to a stone) colored plates of polished rock specimens have been here advantageously introduced. There are also many half-tone plates of buildings in which the various stones have been used. A large number of tests of crushing strength are given

* This Journal, III, vol. xxii, pp. 53 and 132.

and a general résumé states the best uses to which the various stones may be put. The volume shows a large amount of very careful work and is of much more than local interest and value.

L. V. P.

8. *The Cretaceous Formations of the Black Hills as indicated by the Fossil Plants;* by Lester F. Ward, with the collaboration of Walter P. Jenney, Wm. M. Fontaine, and F. H. Knowlton (19th Annual Report of the United States Geological Survey, Pt. II, pp. 521–958, Plates LVII–CLXXII, and 3 sketch maps in text. Washington, 1899).—The foregoing paper is especially marked by a completeness of description and illustration, and a fulness of detail concerning the localities from which plants were obtained, that will materially lighten the labor of future students in this interesting field. It is a very important contribution to American paleobotany.

In the joint work, the determination of *Araucarioxylon Hoppertonæ* as one of the species in the great fossil forests of conifers occurring in the main cycad horizon is by Mr. Knowlton. The identification of plants from the Hay Creek, Wyoming, coal field is by Mr. Fontaine. A number of new species are described, but of much more importance is the recognition of some twenty-five forms also represented in the so-called Lower Cretaceous of Virginia and Maryland, particularly in the Rappahannock and Mount Vernon series of Virginia, and the Aquia Creek series of Virginia and Maryland. The contribution by Mr. Jenney deals with the geology of the Hay Creek coal field, which has evidently been worked out with much care. The remainder of the work, including the determination of plants from the Dakota group proper and the description of twenty-one new species of cycadean trunks, is by Mr. Ward.

From a morphological standpoint the greatest interest centers in the Cycads. The descriptions of these, accompanied by numerous plates, show at once the wealth and beauty of the cycadean flora of the Black Hills. In both the number of species and the completeness of their preservation this locality exceeds any hitherto reported. Bearing in mind the fact that cycadean trunks, although long known from various European Jurassic and Lower Cretaceous horizons, have been among the rarest of fossil plants, these new forms are of much importance. There is just cause for congratulation that, with the trunks procured from the Potomac formation of Maryland, it has become possible to fill up many of the gaps in our knowledge of the distribution and structure of this interesting group of Mesozoic plants.

In describing these Cycads Professor Ward has referred them all to the genus *Cycadeoidea* of Buckland, in this respect not agreeing with most English and continental botanists.

The principal results of these several studies are discussed and given in convenient tabular form at the close. It is decided that in the Black Hills rim below the Fort Benton there is a probable equivalent, at least in part, of the Dakota of Kansas and Nebraska

(Upper Cretaceous No. 1). Further, the cycad trunk horizon, which at Minnekahta is from 60 to 100 feet below this, and 175 feet above the horizon of *Barosaurus* in the Atlantosaurus Beds of Marsh, is held to be Lower Cretaceous,—probably the equivalent of the Neocomian or the Wealden. At the Black Hawk cycad locality the conditions are found to be essentially similar.

It certainly cannot be amiss to point out that we are here concerned with eighty-seven species of plants scarcely a genus of which does not have its Jurassic representative, excluding of course some half dozen plants from just below the Fort Benton, which are apparently Upper Cretaceous. In the lower portion of the strata in question, especially in the Hay Creek region, some distinctly Jurassic plants are present, and when the flora is more fully known they may prove to be more than mere "survivors," as Professor Ward suggests. As has been stated by Professor Marsh, the Cycads of Wyoming, 200 miles farther west where the faunal conditions are held to be essentially similar to those in the immediate vicinity of the Black Hills, are certainly Jurassic. Moreover, in addition to *Barosaurus* from a lower horizon, the strata on the eastern side of "the hills" contain a Dinosaurian genus closely allied to *Stegosaurus* at a distance of at least 150 feet above the marine Jurassic. Between this and the Cycads there are scarcely 100 feet of intervening strata, and no breaks are discernible. All is continuous deposition. The scantiness of knowledge regarding both the faunal and floral record, the difficulty of defining the limits of the European Jurassic, and the fact that these strata though delimited by those two great landmarks,—the marine Jurassic and Fort Benton, are all fresh water, make it clear that the physical record must also be taken into consideration. There are good reasons for believing that here exists an extensive development of distinctly fresh-water Jurassic followed by Wealden equivalents. It is not to be forgotten that farther west the corresponding strata are much thicker. Hence to state now that a Wealden or a Lower Cretaceous equivalent begins a little below the cycad horizon, or perhaps with the "quartzitic cap" just above this which still contains large fossil trees as seen in the Black Hawk locality, would mean the assuming of a difficult position. Unfortunately the conditions which in localities like the Hay Creek region were favorable for the preservation of cycadean foliage were unfavorable to the preservation of trunks, and where the latter occur the leaves appear to have been mostly destroyed. These two facts have thus far prevented our gaining a more exact knowledge of the vertical distribution of the Cycads. While Professor Ward finds ground for a final decision that the Cycads of the Black Hills are not Jurassic, in view of these elements of uncertainty their age will doubtless form the subject of further discussion. G. R. W.

9. *Les Variations périodiques des Glaciers*, 4me Rapport, 1898, rédigé par E. Richter.—This fourth Report of the International Commission on Glaciers has recently been published in

the "Archives des Sciences Physiques et Naturelles" (vol. viii, Geneva, 1899. It contains definite statements as to the recent changes in the glaciers of the Alps, with notes also on those in Scandinavia, Polar regions, Western North America, the Caucasus, Himalayas, and Central Africa. The general conclusions are most complete with respect to the Swiss glaciers. In regard to them Professor Forel remarks that measurements were made in 1898 on some 90 glaciers, 12 of which were shown to be on the increase, while 55 were certainly receding. Of the glaciers not specially observed, the great majority must be admitted to fall also in the latter class, so that we are now in a phase of very general glacial decrease. Of the Swiss glaciers which are at present advancing, several belong to the basin of the Rhone, one to that of the Aar (Rosenlauï) and one to that of the Inn (Rosegg).

In regard to the glaciers of the Eastern Alps, Prof. Finsterwalder concludes that the retrograde movement continues to gain and that the insignificant advances which were manifested in the last few years in a considerable number will probably soon come to an end. It is only rarely that any such decrease is noted as was common formerly; but frequently circles of moraines of recent date are noted, which appear to be entirely wanting in the great period of decrease between 1870 and 1890. Terminal tongues which remain stationary, or nearly so, may disappear on melting, without leaving any trace; while those which have a tolerably rapid motion forward, reform themselves in winter, producing small moraines.

Attention may also be called, in this connection, to the continuation of the paper by C. Rabot, on the variation in length of Arctic glaciers, noticed in this Journal for November, 1897, and July, 1899. The first of these papers appeared in April, 1899, and others have followed in the successive months up to and including November.

10. *On Manganese Nodules found at Onybygambah, New South Wales.*—In view of the wide-spread occurrence, in great depths of the ocean, of manganese nodules such as those observed by the Challenger and other expeditions (cf. the observations by Prof. A. Agassiz on p. 35 of this number), it is interesting to note a description of somewhat similar nodules by W. M. Doherty, as found on the Tweed River in New South Wales, Australia (Australasian Assoc. Adv. Science, vii, 1898, p. 339). He states that he found them extensively scattered over a wide area in the neighborhood of Onybygambah. They varied in size from about that of a pea to that of a Barcelona nut; they were sometimes dark and glossy on the exterior, looking like seeds, and in other cases dull black. A small part of them were perfectly spherical, but the majority, though tending towards this form, were more or less irregular. They were so soft as to be easily broken by the teeth. Three analyses gave the following results:

	Fe_2O_3, Al_2O_3	MnO_2	$MgCO_3$	Organic matter	Gangue	
1.	11·2	24·7	2·0	12·0	49·6 =	99·5
2.	8·7	25·0	2·6	12 8	50·2 =	99·3
3.	14·0	40 6	3·1	10·0	32·1 =	99·8

11. *A Treatise on Crystallography;* by W. J. LEWIS, Professor of Mineralogy in the University of Cambridge. 8vo, pp. 1–612, Cambridge, 1899 (The University Press).—So many of the treatises on crystallography form merely a part of mineralogical text-books, and hence are limited to the every-day requirements of elementary students, that the breadth of the subject might be overlooked, were it not for the occasional appearance of a thorough and exhaustive work. Such an one was presented some years ago by Professor Story-Maskelyne, and we now have another from the hand of Professor Lewis, of Cambridge.

Students of the subject not content with gaining merely such knowledge as is necessary to enable them to handle ordinary crystals, will find much to interest them and require their study in this able and profound discussion. The theoretical relations of rational indices, zone laws, symmetry, and so on, are presented with great minuteness, and then the different classes under the successive systems are taken up in succession commencing with the anorthic system (triclinic). These classes are named in part in a manner analogous to that of Groth, and in part entirely new terms are introduced. For example, under the oblique (monoclinic) system, the *gonioid* class corresponds to the domatic class of Groth (clinohedral group) and the *plinthoid* to his prismatic class (normal or holohedral group). A chapter of one hundred pages is devoted to a thorough discussion of twin crystals, first considered in general, and then with respect to occurring forms under the different systems. Another chapter takes up analytical methods, with a brief classification of other systems of notation than that of Miller, here followed; and the work closes with an account of different forms of goniometers.

12. *Praktische Anleitung zur Analyse der Silikatgesteine nach den methoden der Geologischen Landesanstalt der Vereinigten Staaten* von Dr. W. F. HILLEBRAND. Nebst einer Einleitung enthaltend einige Prinzipien der petrographisch-chemischen Forschung von F. W. CLARKE und W. F. HILLEBRAND. Uebersetzt von Dr. E. ZSCHIMMER; pp. 86. Leipzig, 1899 (W. Engelmann.)—This useful volume is essentially a German reproduction, with some changes chiefly of arrangement, of the general portion of Bulletin No. 148 (1897) of the U. S. Geological Survey. The excellent analytical work carried on in the laboratory of the Survey under the charge of Prof. Clarke, largely by Dr. W. F. Hillebrand, has contributed much to our knowledge not only of the composition of minerals and rocks, but also of the best methods of analysis. It is gratifying, therefore, that this excellent treatise should be put in a form to command a still wider circle of readers.

13. *Darstellung der 32 möglichen Krystallklassen auf Grund der Deck- und Spiegelachsen nebst Beschreibung von Achsenmodellen*

zur Demonstration der Symmetrieverhältnisse der Krystalle von H. Baumhauer; pp. 36, 1 plate. Leipzig, 1899 (W. Engelmann).—The author takes up in the present work the thirty-two classes of crystals, arranged according to their symmetry, and develops the relations between them with much clearness and sharpness. Since fourteen of the classes have no plane of symmetry and twenty-one have no center of symmetry, he prefers to base the fundamental relations upon the axes of symmetry. Of these he distinguishes between two types, the "Deckachsen" and the "Spiegelachsen," the latter being the axes of composite symmetry; these are further defined as "homogene" or "inhomogene," etc. The two classes of the triclinic system fall into an *anaxial* division, and the remaining thirty into the *axial* division; the latter are subdivided into the *monogonal*, *digonal*, *tetragonal* groups, etc.

III. Botany.

1. *How are seeds affected by a temperature of −250° C.?*—Sir W. Thiselton-Dyer gives in the Proceedings of the Royal Society (vol. lxv) a very interesting account of his experiments with seeds under the influence of liquid hydrogen. They are especially instructive when taken in connection with the experiments by Messrs. Browne and Escombe. We give a few extracts from Sir William's paper.

"When Professor Dewar first suggested the experiment to me, he pointed out that it would be a costly one, that it would only be possible to operate on very small quantities of seeds, and that the number of kinds must also be few.

The dozen seeds experimented upon by Messrs. Browne and Escombe, which were submitted to the temperature of liquid air, were apparently selected as belonging to different natural families, and also in some degree as to their composition.* My choice was much more restricted. I took two out of their list for the sake of comparison: barley and vegetable marrow. I added wheat, which had more than once been made the subject of experiment. This gave me two farinaceous seeds and one oily one. I then took shape and bulk into account. Wheat and barley are roughly ellipsoidal and medium in size. The vegetable marrow is relatively large but flattened. I therefore added another oily seed, mustard, which is small and spherical. I followed Messrs. Browne and Escombe in taking a pea, which is also spherical in shape but nitrogenous in composition. Finally I sought a very minute seed, and pitched upon musk.

The list then ultimately stood:

Brassica alba.
Pisum sativum.
Cucurbita Pepo.
Mimulus moschatus.
Triticum sativum.
Hordeum vulgare.

* Roy. Soc. Proc., vol. lvii, p. 161.

The next point seemed to be to eliminate the source of error which might arise from defective germinative power. I therefore communicated the list to Messrs. Sutton & Sons, of Reading, and asked their assistance. With their invariable kindness in any scientific enquiry, they willingly complied, and sent the samples required with the following report:

'We now have pleasure in sending a packet of each of the seeds you name. They are all of last year's growth, and of good germination. For your information we append the germinations arrived at by our tests made in March last of the various parcels from which these samples are taken. We have no doubt that each grain of wheat is a germinating seed, as specially fine seeds have been picked out. In the case of musk a good growth was obtained, but the germination was not counted.

'Germinations:

Mustard	100	per cent.
'Bountiful' peas	100	"
Vegetable marrow	96	"
Musk	Good.	
Wheat	96	"
Barley	100	"

I forwarded the samples (which were small) to Professor Dewar, and suggested that they should be each divided into two portions, one for a control experiment under ordinary conditions, the other to be returned to me after being subjected to cooling. Owing to some misunderstanding, this was not done; but, as will be seen in the result, the omission proved immaterial. The seeds, it should be stated, were simply air-dried: they were ordinary commercial samples, and no attempt was made to further desiccate them. . . . . .

On July 21 he wrote to me:—'In spite of the weather I have carried out my promise, and cooled some seeds in liquid hydrogen for half an hour. I had to seal them up in a glass tube, cool first in liquid air, and then transfer to the hydrogen. They have, therefore, been cooled to $-250°$ C., or $-252°$ C., while being in a vacuum (seeing the air left had no appreciable tension). The seeds in other words, have been transferred to a condition resembling that of moving through space. Another set of the seeds have been cooled only in liquid air for comparison.'

On July 22 he added, on returning the seeds:—'There can be no doubt about the seeds being cooled, as they were in the hydrogen for more than an hour. In fact I used nearly 600^{cc} of liquid hydrogen.'

The seeds came to me in the small packets of tinfoil in which they had been placed in the tube. On opening these it was observed that the seeds were as fresh and bright as before being subjected to the treatment. There was not the slightest dis-

coloration observable in the green tint of the peas. This practically disposed of the only anxiety which Professor Dewar felt as to the success of the experiment, and expressed to me on July 25:—

'My own impression is that unless the sudden vacuum caused by the liquid hydrogen cooling has produced physical rupture of the seeds, they will germinate as usual. If they survive this awful strain, then I believe no increase of the time of cooling could produce any effect other than results from one hour's exposure to such severe cold.'

The seeds were sown in a cool greenhouse, without heat, on July 27. On August 1 they had all germinated. In the case of the mustard, 136 young plants were produced from 155 seeds; the remainder had, however, germinated, but the seedlings had damped off. One of the packets of wheat, for some reason, germinated slightly more slowly than the rest.

On August 5, I received a further packet of the seeds (the musk excepted, indiscriminately mixed. Professor Dewar wrote the same date:—'I have sent you seeds to-day which, if the treatment with cold can kill, ought to be dead. They have been immersed in liquid hydrogen for upwards of six hours, and no attempt was made to graduate the cooling. They were placed in the vacuum vessel into which the liquid hydrogen could drop from the apparatus, and had to take their chance. The seeds have been soaked in liquid hydrogen, and in this respect differ from the last that were cooled in a vacuum from being sealed in a glass tube.'

In this instance again the seeds did not show the smallest visible trace of the ordeal to which they had been subjected. They were sorted out and immediately sown, under the same conditions as before. By August 9 the seeds had all germinated without exception. I communicated the result to Professor Dewar, and he informed me, August 15:—'The temperature Fahrenheit to which the seeds were cooled was —453° F. below melting ice.'

These are the details of the experiment. As it is not likely to be often repeated, I have thought it worth while to place them on record as precisely as possible.

The first question that suggests itself is, what evidence we have for believing that the seeds have actually been brought to the almost inconceivable temperature with which they were surrounded. That they were so brought, Professor Dewar himself has not a shadow of doubt. That substances at widely extreme temperatures can remain in juxtaposition at least for some time, and still maintain them, is illustrated by a striking experiment shown by Professor Dewar at the Royal Institution on April 1, 1898. Liquid air poured into a large silver basin heated to redness remained apparently as quiescent at this high temperature as in cooler vessels, and maintained a spheroidal condition. This is well understood. But the fact remains that liquid air with a temperature of about —190° C. was contained in a vessel which

had a temperature of 800° C., the difference in temperature between the two being 1000° C. . . .

It is probable that plant structures are deficient in thermal transparency, and they are notoriously indifferent conductors. Nevertheless it is difficult to believe that in the case of such small bodies as seeds, their being brought to the temperature with which they are surrounded can be more than a question of time.

That the thermal opacity of at least the seed-coats, may be really considerable is not, however, impossible, even at low temperatures. The following remarks by Professor Dewar have an obvious bearing on this point :—

'Pictet, after an elaborate investigation, concluded that below a certain temperature all substances had practically the same thermal transparency, and that a non-conducting body became ineffective at low temperatures in shielding a vessel from the influx of heat. Experiments, however, prove that such is not the case, the transference of heat observed by Pictet appearing to be due, not so much to the materials themselves, as to the air contained in their interstices. Good exhaustion in the ordinary vacuum vessels used in low temperature work, reduces the influx of heat to one-fifth of what is conveyed when the annular space of such double-walled vessels is filled with air.'*

It is to be noticed that in Professor Dewar's first experiment the seeds were practically in a vacuum. It is obvious from what has been quoted above, that this would help them to retain their heat. Any hesitation in accepting the results of the experiment on this ground is, however, swept away by the second experiment, in which the seeds, with absolutely no protection at all, were actually soaked in liquid hydrogen for six hours. The extremity of caution can hardly resist the conclusion that they must have been brought to the same temperature.

Professor Dewar finds 'that silica, charcoal, lampblack, and oxide of bismuth, all increase the insulation to four, five and six times that of the empty vacuum space.' It might possibly be worth while to try how far a packing of small air-dry seeds would compare, say with charcoal. And this would in some degree be a measure of the thermal transparency of seed structures."

2. *Praxis und Theorie der Zellen- und Befruchtungslehre ;* von Dr. V. Häcker (Freiburg i. Br.) Jena, Gustav Fischer, 1899.

Fixirung, Färbung, und Bau des Protoplasmas ; von Dr. A. Fischer (Leipzig), Jena, Gustav Fischer, 1899.—We have brought these two books together under observation in the present notice, as interesting examples of the exhaustive character of the work which is now going on in that department of investigation which deals with the cell. These studies sweep through the whole range from the suggestive resemblances to organized substances which are found in or can be produced in

* "On Liquid Air as an Analytic Agent," Roy. Inst., April 1, 1898, pp. 7 and 8.

inorganic things, up to the complex factors which are concerned in reproduction of animals and plants. The technique in both these works is precise and special, with explicit directions for procedure which can hardly be misunderstood. The feature which strikes one most forcibly in looking through these excellent handbooks is the entire absence, in the choice of illustrations, of any barrier between the two kingdoms of animals and plants. The recent interesting artificial production of extra-nuclear karyokinetic figures by the employment of certain reagents such as albumose and osmic acid, and the singular imitations of a few of the characteristics of protoplasm, are here presented in almost their latest form, and excite keen curiosity as to the possibilities in this new department of microscopic research. The handbooks are well arranged and are convenient for reference: the indexes being full and useful. G. L. G.

3. *Untersuchungen ueber die Vermehrung der Laubmoose durch Brutorgane und Stechlinge;* by Dr. CARL CORRENS. 1899, Jena. Gustav Fischer; 472 pp., 8°, 187 figures.—In this elaborate monograph, dedicated to the memory of Naegeli by his last pupil, the author gives the results of his histological studies on the non-sexual methods of reproduction in mosses. The number of species studied was so large that the work may be regarded as an encyclopædia of the subject. The author, contrary to the generally received opinion that any cell of a Brutorgan is capable of developing into a vegetative shoot, believes that this capacity is limited to certain cells which he calls Initial-cells. The separation of a Brutorgan is accomplished in two different ways. In the first, or schizolytic, method the rupture is along the middle lamella; in the second, or rhexolytic method, the cells themselves are ruptured and, in the more complicated Brutorgane, certain definitely arranged cells are destined to be ruptured. The author's observations confirm the view that Brutorgane, representing non-sexual growths, are correlated with the sexual, or capsular, growths, so that where the former are abundant the latter are scantily developed or wanting, but he expresses the opinion that the capacity for producing Brutorgane is inherent and is independent of any other property of the species. W. G. F.

4. *Analecta Algologica, continuatio V;* by Professor J. G. AGARDH. Acta. Reg. Soc. Physiogr. Lund, x, pp. 160, 4°, pl. i–iii.—This continuation of the Analecta, with the exception of a short chapter on the new Australian genus of Fucaceæ, *Scœnophora*, treats entirely of Florideæ. There is a revision of the subgenera of the genus Gigartina, with notes on certain species including eleven species from our Pacific Coast, and revisions of species formerly placed in Halymenia and Chrysymenia, from which several new genera are formed. The new genus Collinsia with a single species from California is related to Grateloupia. There is, however, already a genus of phænogams called Collinsia. Among other new American species are *Calosiphona caribæa*, *Dudresnaya canescens*, *Helminthopsis verticillifera* and *Naccaria*

corymbosa from Florida and the West Indies, and *Helminthocladia Batrachopus*, *Meredithia Californica* and *Pyropia Californica* from the West Coast. W. G. F.

5. *The Teaching Botanist: a Manual of Information upon Botanical Instruction, together with Outlines and Directions for a Comprehensive Elementary Course;* by WILLIAM F. GANONG, Ph.D., Professor of Botany in Smith College; pp. xi + 270, with 29 figures in text. New York, 1899 (The Macmillan Company).—Professor Ganong's book occupies a unique field among botanical text-books and is addressed to teachers of botany rather than to their pupils. It is full of the most helpful directions and suggestions and sets forth clearly the aims of modern botanical teaching. The first part is taken up with eight "essays on botanical pedagogics," and the following are among the topics discussed: things essential to good botanical teaching, botanical laboratories, collections and books, scientific drawing and description, common botanical errors. In the second part, an elementary course in botany is described, which is arranged with reference to the principles emphasized in the first part. The topics are carefully selected, so as to illustrate clearly and connectedly the "most vital and illuminating" facts of botany and at the same time to draw out "most quickly and thoroughly" the student's faculties. The essentials of anatomy, morphology, physiology and ecology are taught from flowering plants, as it is deemed advisable to begin with objects more or less familiar to the student, and the course is concluded with a short and general survey of the vegetable kingdom, beginning with the Algæ and ending with the angiosperms. The book is particularly welcome at the present time when the teaching of botany is in a somewhat unsettled state. It is to be recommended not only to teachers of the science but also to those persons who still consider the study of botany as synonymous with the analysis of flowers. A. W. E.

6. *Lectures on the Evolution of Plants;* by DOUGLAS HOUGHTON CAMPBELL, Ph.D., Professor of Botany in the Leland Stanford Junior University; pp. viii + 319, with 60 figures in text. New York, 1899 (The Macmillan Company).—The science of evolution has so often been treated from a zoological standpoint that its principles are fairly well understood. The present account, however, although taken up with topics more or less familiar to the botanist, fills a gap in biological literature, by presenting the subject of plant evolution in a clear and connected manner. The two introductory chapters describe briefly the important facts in regard to the anatomy and physiology of plants and the external conditions under which they grow. The study of plant evolution then begins with a discussion of the "simplest forms of life," including the slime-molds, the bacteria, the Cyanophyceæ and certain of the unicellular green Algæ. This is followed by chapters on the other Algæ, the Fungi, the bryophytes, the pteridophytes, the gymnosperms and the two classes of angiosperms. At all points the interrelationships of the types selected are emphasized,

and the text is frequently elucidated by diagrams representing lines of descent. The author then discusses the geological and geographical distribution of plants, the interdependence between animals and plants, and the effect of environment upon plant-life. Professor Campbell's original work upon the archegoniates and the lower monocotyledonous plants has particularly fitted him for writing a book of this character. A. W. E.

7. *Botanizing: a Guide to Field-Collecting and Herbarium Work;* by WILLIAM WHITMAN BAILEY, A.M., Professor of Botany in Brown University; pp. ix + 142, with frontispiece and 15 figures in text. Providence, R. I., 1899 (Preston & Rounds Company).—The Botanical Collector's Handbook, published by Professor Bailey nearly twenty years ago, is well known to botanists and will give an idea of the matters treated in the above work. The new book, however, is entirely rewritten and has incorporated in it many new and important observations and directions. In discussing the collection and preservation of the willows, the mosses, the Algæ and the Fungi, the author has engaged the help of specialists. A. W. E.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Life of James Dwight Dana, Scientific Explorer, Mineralogist, Geologist, Zoologist, Professor in Yale University;* by DANIEL C. GILMAN, pp. 1–409. New York, 1899 (Harper Brothers).—In this biography, which the author describes as "personal rather than scientific," an admirable sketch is given of both the personality and work of one who for a full half-century was a central figure in the development of Natural History in North America. Had he not left the impress of his life upon the very details of the several sciences he advanced, such a brief sketch would be far from satisfactory. Brief as it is, one catches from its reading the inspiration of the busy life and is overwhelmed with the prodigious amount of work accomplished in a single lifetime.

The author has performed his part with great skill, adding to his wide knowledge of science a keen appreciation of the personal characteristics of Professor Dana, with whom few of those who survive him (due to his delicate health) had the privilege of intimate acquaintance.

A single sentence in a letter to Guyot, written two days after his fifty-second birthday, vividly expresses the noble spirit of his life. "I feel anxious to work, and work effectually, while the day lasts, having a constantly augmenting realization of the greatness and extent of the work to be done to keep science headed aright in these times." (p. 330.) W.

2. *November Meteors of 1899.*—Further reports confirm the comparatively slight character of the Leonid shower this year. The maximum density seems to have occurred on the night of November 14–15, when it was clear in Canada and neighboring

regions, and a considerable display was observed at Montreal. Rev. Joel H. Metcalf reports that at Burlington, Vermont, 93 Leonids were seen by his party on that night between 1 A. M. and dawn, and he was successful in securing one or two meteor-trails by photography. Our knowledge of the distribution of the bodies forming the stream is likely to grow very slowly, as, if the period is $33\frac{1}{4}$ years, we shall not encounter this part of the stream again until the year 2032.

Quite a display of Andromedids was observed on the nights of November 23 to 25, Professor Young of Princeton, New Jersey, having seen, according to press reports, as many as 10 per minute on the latter night for a short period. At New Haven it was clear on November 23 and 24 and on the latter night a number of trails were photographed, one of which was secured at both of the Observatory stations and will thus afford a determination of its position, direction, and velocity. W. L. E.

3. *The Aims and Methods of Meteorological Work especially as conducted by National and State Weather Services;* by CLEVELAND ABBE.—This interesting paper is reprinted from Part III (pp. 219–330) of the Report on the Meteorology of Maryland, prepared by Cleveland Abbe, O. L. Fassig, and F. J. Walz by direction of Willis L. Moore, Chief of the U. S. Weather Bureau.

The Maryland Weather Service is under the directorship of Prof. W. B. Clark, whose excellent work on the Geology of Maryland has already resulted in the production of the valuable and handsome volumes before noticed in this Journal. The present paper is a popular survey of the entire subject of meteorological work, especially in its application to the State of Maryland. The principles involved in the prediction of storms, wind, frost, fog and other important weather conditions, are explained very clearly. Then the various elements involved in climatology are explained, and finally the special apparatus and methods employed in observations of temperature, wind, velocity, atmospheric pressure, etc. The whole forms an admirable chapter for the instruction of that large part of the public which, though interested, has little definite information in this direction and is too slow to recognize the high standard and constantly progressive character of the work done by our Weather Bureau. It is profusely illustrated with excellent plates and published in the same liberal way as the other volumes from the same source.

4. *Our Native Birds:* How to protect them and attract them to our Homes; by D. LANGE; pp. 1–162, 12mo. New York, 1899 (The Macmillan Company).—This attractive little book is especially designed to aid in the most laudable effort to protect our native birds, particularly by those means which cannot be made matters of legal requirement. The author calls attention to the fact that though it is easy to pass laws against recognized evils, it is much more difficult to provide means for enforcing their provisions. Hence the suggestions which he makes here are most valuable, and it is to be desired that they should find wide adoption.

5. *The Elements of Blowpipe Analysis;* by FREDERICK HUTTON GETMAN, Instructor of Chemistry in the Stamford High School; pp. 77, 12mo. New York, 1899 (The Macmillan Co.).—This little book contains a brief outline of the methods of blowpipe analysis, and a statement of the general reactions of prominent substances and compounds; also a description of the most common ores of the different metals, with full statement of their blowpipe characters. It will be found useful by those who do not desire to use one of the large and detailed manuals.

OBITUARY.

SIR JOHN WILLIAM DAWSON.

It is with deep regret that we record the death of Sir William Dawson, which took place at Montreal on November 19th in the 79th year of his age. By his death Canada loses a distinguished geologist as well as one who was intimately identified with educational work of all kinds, but more especially with higher education, in the Province of Quebec.

He was born at Pictou, Nova Scotia, on October 13th, 1820, his father being a shipbuilder in that town, and studied at Pictou College and subsequently at the University of Edinburgh, under Jameson, Forbes and Balfour. He returned to Nova Scotia in 1847 and three years later, having already attracted some attention by the publication of a number of papers, reports and lectures, he was appointed Superintendent of Education for that Province. His work in connection with this position obliged him to travel continually through all parts of Nova Scotia, and on these journeys he accumulated the materials for his largest work, that entitled "Acadian Geology." While carrying on this work he met Sir Charles Lyell, with whom he studied the now celebrated Joggin's Section on the Bay of Fundy.

In 1855 Sir William was appointed to the Principalship of McGill University, a position which he held until 1893. He was at the same time Professor of Geology, and the University prospered under his management beyond the most sanguine expectations of its friends. In addition to administering the affairs of the University and delivering several courses of lectures every year, he was first and foremost in every movement to further education and also found time to carry on original work along several lines, achieving very valuable results. He was also the author of many popular books on scientific subjects, more especially in connection with geological science.

In 1883 he traveled extensively in Egypt and Syria, studying the geology of these countries and its relation to sacred history.

He took an active part in the organization and proceedings of the meeting of the British Association for the Advancement of Science, held in Montreal on the following year, on the occasion of which he received the honor of knighthood.

In 1893 Sir William was seized with a very severe attack of pneumonia and his health became so seriously impaired that he was obliged to give up work for a time and spend the winter in the south. His strength, however, was not restored, and he resigned his position as Principal of McGill University in 1894. During the later years of his life his strength gradually ebbed away and what little work he could undertake consisted in arranging his collections and working up some unfinished papers. Several of these were published in 1894 and 1895, but the years of quiet labor to which he looked forward at this time, were cut short by a series of sharp attacks culminating in partial paralysis, which forbade further effort. He passed away on the 19th of November very peacefully and without pain.

Lady Dawson, with three sons and two daughters, survive him. His eldest son, Dr. George M. Dawson, the present Director of the Geological Survey of Canada, has inherited his father's love for geological work and has achieved wide distinction in the world of science.

Sir William's first original contribution was a paper read before the Wernerian Society of Edinburgh in 1841 on a species of field mouse found in Nova Scotia. From that time onwards he was a continuous contributor to scientific journals and to the publications of learned societies.

The most important work of his earlier years was an extended study of the geology of the eastern Maritime Provinces of Canada, the results of which are embodied in his "Acadian Geology" already mentioned, a volume of nearly 1000 pages accompanied by a colored geological map of Nova Scotia, and which has passed through four editions. He subsequently devoted much time to various researches in palæobotany, more especially in connection with the Upper Silurian, Devonian and Carboniferous systems of eastern Canada and of the Cretaceous and Tertiary of the western portion of the Dominion. The results of these researches were published in a long series of papers which appeared chiefly in the Quarterly Journal of the Geological Society and in the Transactions of the Royal Society of Canada. He also contributed a volume entitled "The Geological History of Plants" to Appleton's International Scientific Series.

In 1863 he published his "Air Breathers of the Coal Period," which contained the results of many years study of the fossil batrachians and land animals of the Coal Measures of Nova Scotia, the earliest known remains of Microsauria having been discovered by him in the interior of decayed tree stumps in the Coal Measures of South Joggins. The results of his later studies of these creatures were embodied in a series of subsequent papers

Sir William also while residing in Montreal, devoted much at.

tention to the Pleistocene deposits in the vicinity of the city and in fact to those of eastern Canada generally, especially to the remarkably rich invertebrate fauna which they contain. His "Canadian Ice Age" embodies the chief results of this work and is one of the most important contributions to the palæontology of the Pleistocene in America, which has hitherto appeared.

His work in connection with Eozoon Canadense is well known. Sir William was also a prolific writer of popular works on various geological subjects. Among these may be mentioned his "Story of the Earth and Man," his "Fossil Men and their Modern Representatives," his "Meeting Place of Geology and History," and many others. These books, written in a very entertaining style, had a wide circle of readers. Many of these volumes as well as many papers contributed to various religious papers treated of the relation of science and religion. He was a Presbyterian of the old school and strongly opposed to all theories of the evolution of man from brute ancestors, nor would he allow anything more than a very moderate antiquity for the species. The study of geology, too, he would have emancipated from "materialistic infidelity which, by robbing nature of the spiritual element and of its presiding Divinity, makes science dry, barren and repulsive and diminishes its educational value."

These works on the relation of science and religion, while they undoubtedly met a popular demand, have but a transitory value and are not those by which Sir William Dawson will be remembered. His reputation will rest on his great contributions to our permanent stock of knowledge, representing achievements of which any man might well be proud.

His name has been perpetuated in connection with the geological work of McGill University by the erection of a second chair in geology to be known as the Dawson Chair, which has just been endowed by Sir William Macdonald.

Sir William was a man of quiet geniality, gentle and even deferential in manner, but decided in opinion and firm in action. The preëminent note of his character was sincerity and singleness of purpose. His loss will be felt by all who knew him, but especially by the members of the University with which he was so long connected. FRANK D. ADAMS.

DR. HENRY HICKS, the English geologist, best known for his able investigations of the pre-Cambrian rocks of Wales and Scotand, died on November 18th, at the age of sixty-two years.

Graftonite, a New Mineral,

Is described in this number of this Journal by Prof. S. L. Penfield. The entire supply is ours and no more is obtainable at the locality, which Mr. English visited in June and has since had thoroughly explored. The remarkable and entirely unique intergrowth of Graftonite and Triphylite observable in every specimen, will give this mineral a place in every scientific collection. It is not, however, a beautiful mineral. Prices, \$2.00 to \$5.00 for good cabinet-size specimens; \$5.00 to \$20.00 for the six or eight specimens which show crystallization; 50c. to \$1.00 for small pieces.

SILICEOUS CALCITE CRYSTALS.

A large assortment of the most curious South Dakota "Fontainebleau Limestones" is now en route and will probably arrive about the first of the year. Further particulars of this very interesting lot will be given next month.

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63 specimens from Michigan, a new find, at exceedingly low prices, 10c. to \$1.00. The specimens show veins and blotches of the mineral attractively scattered through the matrix.

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125 good, loose crystals. Their faces are brilliant and the crystals well formed. 10c. to 25c. each.

EMERALD-GREEN FLUORITE.

Such remarkably rich-colored material was secured by our Mr. Fraser at the Westmoreland, N. H., locality during his visit in November, and so much enthusiasm has been manifested over the specimens that it affords us pleasure to announce that another visit to the locality was made in December which resulted in our securing a 99 years' lease on the mine. As the most richly-colored material is found loose in the soil and not in the vein, it seems probable that but little more will be found. Fine cleavage octahedrons, 5c. to 35c.; splendid masses of magnificently colored fluorite, crudely crystallized, 25c. to \$2.00.

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A single fine specimen of **Dioptase from Arizona** is worthy of note because of its excessive rarity and modified crystals; \$15.00.

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[FOURTH SERIES.]

ART. VIII.—*Sedimentary Rocks of Southern Patagonia;* by J. B. HATCHER. With Plate I.

SINCE publishing my last paper on the geology of southern Patagonia,* I have spent two years in that region making a further study of its geology and bringing together important additions to our collections of fossil vertebrates and invertebrates. The results of these two additional years of field work, together with the more advanced stage now attained in the study of our collections of fossils, have greatly augmented the observations made during my first expedition and materially modified several of the opinions expressed in my former paper regarding the age and relations of the various sedimentary deposits of Patagonia.

Chief among the additional observations and resultant modifications of the former views as expressed in my first paper may be mentioned: First, the discovery near Sandy Point, in the Strait of Magellan, of an entirely new series of Tertiary deposits several hundred feet thick and underlying the *Patagonian beds.* These new Tertiary deposits have already been noticed by Dr. A. E. Ortmann and have been named by him the *Magellanian beds.*† Second, the discovery near Lake Pueyrredon of several distinct fossil-bearing horizons in the Cretaceous.

Chief among the changes which it now seems necessary to make regarding the geologic position and relations of the vari-

* See this Journal, vol. iv, pp. 327-354.

† See this Journal, vol. vi, 1898, pp. 478-482, and vol. viii, pp. 427-432.

ous sedimentary deposits as expressed in my forme paper are: First, the age of the *Patagonian beds.* A study of the very extensive collections of invertebrate fossils which we now possess from the *typical Patagonian beds* makes it necessary to remove this entire series of strata from the Eocene, where we had formerly placed it, and to refer the rocks composing them to late Oligocene and early Miocene. Second, extensive observations in the *Patagonian* and *Supra-Patagonian beds* at many different and widely separated localities, has demonstrated beyond a doubt the identity of these two deposits, which were formerly supposed to be quite distinct and separated by a considerable period of time. Third, an interstratification has been observed between the upper Supra-Patagonian and lower Santa Cruz beds. This condition was first noticed and has always been maintained by Florentino and Carlos Ameghino. It was erroneously opposed by myself in my former paper, due to insufficient observations on my part at that time.

These additional observations and necessary corrections to my first paper, together with many other observations of scarcely less importance made during the past two years, render it advisable to record here the principal geologic features observed, and to give a correlation of the various sedimentary rocks now known in southern Patagonia based upon our present more advanced study of the fossils found in them and upon a comparison of these fossils with fossil forms from North America and Europe found in beds the age of which has been determined beyond a reasonable doubt both from paleontologic and stratigraphic evidences.

It will be the purpose of the present paper to give a brief description of the geology of southern Patagonia, together with a short discussion of the age of the various sedimentary deposits found there. A more detailed treatment of the geography, topography, stratigraphy and general geology of the region in question will be reserved for chapters under those heads, which will appear in one of a series of monographs to be issued by the department of geology and paleontology of Princeton University upon the natural history collections made by the University expeditions to Patagonia. This series of monographs is now in preparation, most of the material having already been placed in the hands of competent specialists in each department. Its early publication in a creditable manner has been made possible by the munificence of a friend of science.

That portion of Patagonia of which it is the purpose of this paper to treat lies beyond the 46th parallel of south latitude. A map of the region, including Tierra del Fuego and the

adjoining islands as far south as Cape Horn, has been prepared to accompany the present paper.

While most of the more important geographic features at present known are located on the map, especial attention has been given in its construction to indicate all those features which, though of little purely geographic interest, might prove of considerable value to any field geologist who in the future may wish to examine the same localities visited by myself for the purpose of verifying my observations. It is believed that with the text and accompanying map in hand it will not be a difficult matter for any fairly competent person to identify the different localities mentioned in the text or to verify the stratigraphic sections herein described.

The great value of explicit descriptions concerning the location of important geologic sections and of the surface exposures of new or little known geologic horizons, especially, as frequently happens, when such exposures are of limited area, must already have become apparent to working geologists everywhere. This is especially true in a little known and sparsely settled or entirely unsettled country like the interior of Patagonia. In the progress of my work in Patagonia I have been materially handicapped by the want of just such explicit and accurate descriptions of localities as I have myself always endeavored to give in all my published papers relating to the geology of the fossil fields of either North or South America.

In naming and defining a new geologic horizon it appears to me that the discoverer, if endowed with a true scientific spirit and considering the best interests of his chosen science, will be impelled to give at least one definite locality where the horizon may be found well represented and containing the fossils characteristic of it, when such fossils are known to exist anywhere in the newly-discovered beds. It should not be considered sufficient to say that certain beds are found represented "in the region of Lakes Viedma and San Martin" when the limits of these lakes are separated by a distance of more than 100 miles. Nor after describing an exceedingly important geological section is it enough to add that "this section is shown in a bluff in the region of Lakes Colhue and Musters," since the limits of these lakes, both of large size, are separated by long distances.

The want of more explicit information regarding localities, due perhaps to thoughtlessness on the part of Dr. Ameghino, has rendered much of my work in Patagonia necessarily a work of exploration and not so productive of paleontologic and geologic results as it would have been, had I been possessed of data enabling me to go directly to localities previously discovered by Señor Carlos Ameghino.

The map prepared and published by Dr. Francisco P. Moreno in the Geographical Journal of the Royal Geographical Society of London, accompanying a paper by the same author entitled "Explorations in Patagonia" and published in the September and October numbers of the same Journal for 1899, has served as the basis for the present map. It has been redrawn by Mr. Howard Logan, with the introduction of a few additions and corrections made by myself. The map is essentially the work of the Argentine Limit Commission under the direction of Dr. Moreno. While not complete it is fairly accurate and is by far the best of any of the maps yet published of this region.

Physiographic Features of Patagonia.

Before entering upon a discussion of the geology of Patagonia it may be well to refer briefly to the principal physiographic features of the country.* Patagonia and Tierra del Fuego are naturally divided into two sharply defined and easily characterized regions, a western, extremely mountainous, region and an eastern, comparatively level, plain. The mountains of the western region are formed by three parallel ranges separated by two deep, narrow, longitudinal valleys. Throughout the eastern plains region several features combine to break the monotony and lend variety to what would otherwise be an exceedingly dreary landscape. Chief among such features are the great transverse valleys that cross the Patagonian plains from east to west and form the principal drainage systems of those plains. These valleys frequently attain a depth near the Andes of more than 2000 feet below the surface of the neighboring plains. They are all true valleys of erosion, while the longitudinal valleys of the western mountainous region are of tectonic origin. It is along the bluffs of the sea and in the exposures over the slopes of these valleys and their less important tributaries that the best opportunities are offered for studying the geology of Patagonia.

MESOZOIC.

Jurassic?—The oldest sedimentary rocks observed by the writer anywhere in Patagonia consist of a series of black, very hard but much fractured slates with remains of Ammonites fairly abundant but not sufficiently well preserved to admit of identification. These beds I have already noticed in my former paper on the geology of Patagonia, and have named

* For a further description of the geographic features of Patagonia, see paper on that subject by J. B. Hatcher in The National Geographic Magazine, Feb. 1900.

them the *Mayer River beds*, from the name of the river in the bluffs of which they were found. The localities where they may be observed were described in my first paper, and it is only necessary to remark here that neither their upper or lower limits have as yet been definitely determined. No additional evidence has been gained regarding their age, and they are provisionally referred to the Jurassic chiefly on account of the great thickness of the sedimentary rocks overlying them, which from the remains of Dinosaurs found somewhat abundantly in their upper members can scarcely be considered of more recent age than Cretaceous.

Cretaceous.

Pueyrredon Series.—Under this name I include some 800 feet of rocks observed in the vicinity of Lake Pueyrredon. The strata forming the *Pueyrredon Series* are immediately but unconformably overlaid by the variegated sandstones, *Areniscas Abigarradas beds* of Ameghino. The rocks of the *Pueyrredon series* are well exposed and may be conveniently studied on the left bank of Rio Tarde, some four miles above where that stream empties into the east end of Lake Pueyrredon. At about that distance from its mouth this small stream runs through a deep cañon, that has been cut in the eastern foothills of the Andes, and enters the broad level valley that extends eastward from the eastern extremity of the lake. Following the bed of the stream up the cañon to its source, there may be seen the most extensive and best exposed geologic section observed anywhere in Patagonia during my explorations in that country. Some 5,000 feet of sedimentary rocks are exposed in a continuous section extending from the Lower Cretaceous to late Pliocene deposits. Many distinct geologic horizons are represented and most of them are fortunately rich in fossil remains in an excellent state of preservation.

Gio beds.—Starting at the base of the section and at the mouth of the cañon, a deposit of soft green sands or marls about 100 feet thick are seen. Included in the green sands are several harder, brown layers, each about two feet thick and composed largely of shells of Exogyra. The proximity of this outcrop of these beds to Lake Gio and the Gio basin has suggested the name *Gio beds* for these green and brown sandstones. These beds dip gently to the southwest and their inclination, together with the rapid increase in the elevation of the bed of the stream as one proceeds up the cañon, soon brings the 100 feet* of strata composing them beneath the

* The thickness of the various deposits given in this section are based on barometric observations of altitudes: due allowance in each case was made for the dip of the different beds. While not absolutely correct, it is believed they are fairly accurate.

bottom of the cañon. Thus at a distance of only two or three hundred yards from the mouth of the cañon the top of the *Gio beds* appears at and passes beneath the bed of the stream.

Lower Conglomerates.—The *Gio beds* are immediately and apparently conformably overlaid by about 20 feet of hard, rather fine conglomerate, which will be designated the *Lower Conglomerate.* In this conglomerate were found occasional pieces of petrified wood filled with the shells of small boring mollusca. No other fossils were observed in this conglomerate.

Belgrano beds.—The conglomerates soon disappear beneath the bed of the stream and are seen to be conformably overlaid by about 300 feet of soft, greenish sandstones and clays, replaced toward the top by several layers of harder sandstones and impure limestones, each usually of only a few feet in thickness and appearing as ledges projecting from the side of the cañon. These 300 feet of strata we shall call the *Belgrano beds* from Lake and Mt. Belgrano, located some distance to the southward. These beds, especially toward the top of the series, are rich in the fossil remains of characteristic Mesozoic invertebrates. A few imperfect plant remains were also found, and a very few small, trituberculate teeth were discovered associated in the same rock with remains of Ammonites. These trituberculate teeth may perhaps pertain to mammals.

A considerable collection of invertebrates was made from the Belgrano beds at this locality and from another exposure of the same beds discovered some eight miles farther east. These collections, together with those made from the underlying *Lower Conglomerate* and *Gio beds*, have been placed in the hands of Dr. T. W. Stanton, who has already made a preliminary study of them and writes as follows: "Although not specifically identified, the relationships of many of the forms are such that there is no doubt of their Cretaceous age, and I am at present inclined to place them not earlier than about the middle of the Cretaceous, say Gault or Cenomanian. This is subject to revision, however. The Trigonias show close relationship with species from the Uitenhage beds of South Africa, which I believe are now generally assigned to the Lower Cretaceous." The Cretaceous age of these beds as determined by Stanton from a study of the invertebrate collections is significant, since Dr. Ameghino, after seeing two of the small teeth collected by myself from them, immediately referred this entire series of beds to the Jurassic.*

* See Sinopsis Geologica-Paleontologica por Florentino Ameghino (En Segundo Censo Nacional de la Republica Argentina, tomo 1, pp. 111–255, con 105 figs, Buenos Aires, 1898, en folio) Supplemento (Addiciones y Correcciones) Julio de 1899, p. 13.

Upper Conglomerates.—The *Belgrano beds* in the cañon of Rio Tarde are conformably overlaid by 330 feet of hard fine-grained red and variegated sandstone with occasional layers of clay ending above in a series of very hard fine conglomerates. No characteristic fossils were found in these beds, which may be called the *Upper Conglomerates* as distinguishing them from the *Lower Conglomerates* near the base of the series. A somewhat careful search for fossils was rewarded only by the discovery of a few imperfect plant remains and one or two casts of bivalve mollusca.

Thus far all the rocks of the entire series of strata through which we have passed in ascending the lower one and a half miles of the course of the cañon are conformable and evidently of marine origin. Taken together they constitute the *Pueyrredon Series*, with an aggregate thickness of from 750 to 800 feet.

The present surface distribution of rocks belonging to the *Pueyrredon Series*, known to the writer from personal observations, is of very limited extent and is confined to the lowermost 800 feet of strata exhibited in the lower course of the cañon of Rio Tarde and to other very limited exposures to be seen about eight miles to the eastward, in a small cañon cut in the surface of the first bench, which at this point has an altitude of some 200 feet above the bottom of the valley of Gio basin which extends eastward from Lake Pueyrredon. In this vicinity the bottom of the valley of Gio basin is occupied by a lake shown on the map as White Lake, and the exposures in question will be found at a distance of about two miles south of the western border of this lake. They are neither conspicuous nor extensive, but are exceedingly rich in well-preserved fossil remains. From verbal descriptions by Dr. F. P. Moreno, I infer that outcrops of the same series of beds may be seen in the region between Lakes Argentino and Viedma and lying west of the Rio Leon. Certain beds discovered by Dr. Rodolfo Hauthal in the vicinity of Last Hope Inlet, appear also to belong to this series.

Dr. Ameghino has on several occasions in his published papers referred to certain beds containing Cephalopod remains, in each instance almost invariably applying to them a different name and assigning them to the Jurassic without giving any reasons whatever for so doing. Since Dr. Ameghino gives no localities where his so-called *Jurassic beds* may be found and nowhere characterizes them, either by giving adequate descriptions of their lithological characters or specific and generic lists of the fossils contained in them, I have been unable to identify any of his Jurassic? horizons except the one referred to above in speaking of the small teeth collected by myself

and shown to Dr. Ameghino. This horizon, as has already been shown, belongs to the Cretaceous and not to the Jurassic. It seems probable that Dr. Ameghino has in each instance, as is evident in this one, when dealing with these marine Mesozoic horizons, based his remarks on the discoveries and observations of others and made his correlations to agree with his own preconceived ideas; instead of submitting such correlations to and abiding by the judgment of specialists in Mesozoic invertebrates.

Although the present known surface distribution of the rocks of the *Pueyrredon Series* is exceedingly limited, it is quite probable that future explorations will show that they are represented in a more or less continuous series of outcrops extending all along the eastern range of the southern Andes.

San Martin Series.—In this series it is proposed to include some 3,500 feet of Upper Cretaceous rocks, for the most part well represented at various places throughout southern Patagonia and more especially in the region lying directly east of Lake San Martin.

The Areniscas Abigarradas beds.—These beds, also frequently referred to as the *Variegated Sandstones*, lie at the base of the San Martin series. They are well represented in the bluffs along the south shore of the east end of Lake Pueyrredon and of the deep valley extending eastward from that lake. In the cañon of Rio Tarde they may be seen in a series of hard, well stratified sandstones 1,350 feet thick, overlying the *Upper Conglomerates* of the *Pueyrredon Series*, with which they appear slightly unconformable. They are usually fine-grained and of varying colors, with light pinks and pale greens predominating. They are exceedingly barren of fossils, a somewhat careful search at this and several other localities being rewarded by the discovery of only a few imperfect and uncharacteristic plant remains.

The rocks of the *Areniscas Abigarradas beds* have a much more extensive surface distribution than any of the other Cretaceous deposits of southern Patagonia. They appear over large areas all along the eastern base of the Andes and are known to cover a considerable portion of the interior plains region lying to the eastward of Lakes Pueyrredon and Buenos Ayres, extending even to the Atlantic coast, as may be observed at Port Desire. They also outcrop at intervals in the valley of San Julian, which extends inland for many miles from the head of the present bay of the same name.

Owing to the great thickness and uniform hardness of these sandstones as compared with most of the other sedimentary deposits of southern Patagonia, wherever found, they form

the principal and most striking topographic features of the region. In the cañon of the Rio Tarde they form vertical walls that for a considerable distance maintain an average height of more than 1,000 feet. They are referred to the Upper Cretaceous entirely upon stratigraphical evidences. Since they have been seen to rest unconformably upon the 330 feet of *Upper Conglomerates* which separate them from the underlying *Belgrano beds*, the latter, according to Stanton not older than *Gault* and perhaps *Cenomanian*, they must therefore be considered as belonging somewhere in the *Upper Cretaceous*.

Lower Lignite beds.—Under this head I include a series of beds consisting at the base chiefly of a fine, gray, volcanic ash deposit, passing upwards into a series of rather soft red and gray sandstones. These beds are entirely wanting in the Lake Pueyrredon and Rio Tarde sections, but may be seen in the bluffs on the south side of Mayer Basin, and especially on the left bank of the south fork of Rio Chico about three miles above Shell Gap. At this locality these beds have an estimated thickness of 1,500 feet and contain in great abundance partially lignitized, partially petrified trunks and branches of trees. In several instances vast accumulations of such tree trunks were observed, frequently forming the chief constituent of beds twenty to thirty feet thick and of unknown lateral extent.

I have nowhere observed the *Lower Lignite beds*, except about the headwaters of the south fork of the Rio Chico on the south side of Mayer Basin, where they unconformably *overlie the Variegated Sandstones*. Notwithstanding the exceedingly promising appearance of these lignite beds, an extended search in them for fossil remains was not rewarded by the discovery of any animal remains whatsoever. No definite opinion can at present be advanced as to their probable position in the Upper Cretaceous.

The Guaranitic beds.—The Guaranitic or Dinosaur beds consist of a series of soft, dark or mottled clays and shales with occasional layers of bright red, green and orange-colored materials of very fine grain. The finer of these colored deposits are mixed with grease and successfully used by the Tehuelche Indians as mineral paints, in the decoration of their person, wearing apparel and other articles.

The *Guaranitic beds*, like the underlying *Lower Lignite beds*, are entirely wanting in the Rio Tarde and Lake Pueyrredon sections, but are well represented in the region about the headwaters of the south fork of the Rio Chico and in the high bluffs on the south side of Mayer Basin between the sources of the last named stream and an eastern tributary of Mayer River

rising in the same range of bluffs. In this region these beds have an estimated thickness of 500 feet. They also occur in limited areas along the upper course of the Rio Chalia or Shehuen and at intervals over the central interior region lying between Port Desire and the eastern base of the Andes. In the latter region they are usually found occupying depressions eroded in the surface of the variegated sandstones and of certain porphyries and basalts of unknown age that occur here over considerable areas.

The Guaranitic beds contain fairly abundant Dinosaurian remains, but several weeks spent in them at different times and in various localities has resulted in a fruitless search for representatives of that rich, varied and highly specialized mammalian fauna which they are said by Dr. Florentino Ameghino to contain. On the other hand, Señor Carlos Ameghino, who has collected most of the material for his brother Florentino, assured the writer, during an interview with him in Santa Cruz, in July, 1898, that he had never found either Pyrotherium or any other representatives of the Pyrotherium fauna associated with Dinosaurian remains. Carlos Ameghino was very positive in his statements to me regarding this matter, and when shown Dr. Ameghino's statements on this subject as translated and published in The Geological Magazine of January, 1897, in an article entitled "Geology and Paleontology of Argentina," he said that there had been a mistake in the translation or that his brother had entirely mistaken his statements concerning the manner in which he had found the fossils of the respective faunas. He also informed me on the same occasion that previous to the expedition from which he had then but just returned to Santa Cruz, he had never found any mammalian remains whatsoever associated with the remains of Dinosaurs. On his last trip however he said he had found a few small multituberculate teeth associated with Dinosaurian remains in the *Guaranitic beds* on the upper course of the Rio Shehuen. These are Señor Carlos Ameghino's statements to me concerning the stratigraphic relations of these Dinosaurian and Mammalian faunas. It will be noticed that they agree on the whole with the published statements of Drs. Santiago Roth and Alcides Mercerat. They also explain why I have been unable to find the Pyrotherium fauna associated with the Dinosaurs. Such mistakes based on misunderstandings are always liable to occur, and are excusable where, as was the case in this instance, the author was recording not his own observations but the impressions left upon him by the narration of the observations of another, made in a region with which he was himself not only unfamiliar but entirely unacquainted.

The Guaranitic beds are referred to the Upper Cretaceous both upon stratigraphic and paleontologic evidences. Just

where they should be placed in that series cannot be determined until we know more of the Dinosaurs contained in them. At present it seems not improbable that they will prove to be the equivalent of the Laramie of North America, as they have long been considered by Dr. Ameghino and others.

With the *Guaranitic beds* we have reached the uppermost of the Mesozoic strata known not only to Patagonia but to South America, and assuming that they represent the Laramie we find the close of the *Mesozoic Era* in the southern hemisphere as in the northern marked by an abundance of gigantic and highly specialized Dinosaurs associated with the remains of an exceedingly scanty mammalian fauna, its representatives of small size, of generalized types and exhibiting even a less degree of differentiation and specialization than has been observed in the north.

Taken together the *Variegated Sandstones*, *Lower Lignites* and *Guaranitic beds* constitute the *San Martin Series*, of Upper Cretaceous age. The last two should perhaps be entirely separated from the Variegated Sandstones and considered as a distinct series, since they are unconformable with them and were very likely of largely fresh-water and aëolian origin, while the sandstones, on account of their vast extent and homogeneous nature, would seem to have been deposited in a great open body of water, probably marine, over which precisely the same relative conditions prevailed for an infinitely long period of time.

Tertiary.

For a long period following the deposition of the *Guarantic beds* all this region was elevated and subjected to erosion. During this long period of early Tertiary erosion the entire series of strata constituting the Guaranitic and Lower Lignite beds were in many places completely carried away, as has evidently been the case in the Lake Pueyrredon region; while in the vicinity of Lake San Martin and at various localities over the interior, remnants of the Guaranitic beds are still left having partially resisted the early Tertiary erosion to which they were subjected. The valleys which were then cut deep in the surface, frequently passing quite through the Guaranitic and Lower Lignite beds and into the rocks of the Variegated Sandstones, may now be seen in many localities filled with a series of Tertiary deposits varying in age from early Eocene to Pliocene. Such deposits have been sometimes of marine, sometimes of fresh-water or aëolian origin. The complex nature of the stratigraphy of the region in which they now occur, due to the eroded nature of the surface upon which they were laid down, has led Dr. Ameghino to consider such

Tertiary deposits as interstratified with the Guaranitic beds and Variegated Sandstones and therefore of Cretaceous age. Formerly Dr. Ameghino considered all of such Tertiary deposits as of one age and belonging to one series, which he designated as the *Pyrotherium beds.* In my former paper I pointed out that in the *Pyrotherium beds* of Ameghino there were represented two or more distinct horizons. I at the same time suggested that some of the fossil mammals described by Ameghino as from the *Pyrotherium beds* appeared to belong to a formation more recent than the *Santa Cruz beds.* Further explorations in Patagonia have only confirmed my former views and Dr. Ameghino has since partially adopted these views. He has now divided his Pyrotherium fauna into two faunas, referring one to the Middle and the other to the Upper Cretaceous. Unfortunately he has not yet recognized the true stratigraphic position of the beds in which the various faunas were found with reference to the *Guaranitic beds.* A further subdivison of this Pyrotherium fauna is necessary and a recognition of the *Miocene*, *Pliocene* and *Pleistocene* nature of several of the forms included in it. Among such Pleistocene forms will be found the large gravigrade edentate described by Ameghino as not distinguishable from Mylodon and more than likely Pyrotherium, which resembles very closely some of the larger Pleistocene herbivorous marsupials of Australia. Unfortunately I have not as yet been able to find any remains of Pyrotherium and have, therefore, been unable to determine its exact stratigraphic position. It is interesting to note, however, that Dr. Santiago Roth, who has spent two years collecting in beds which according to Ameghino contain his Pyrotherium fauna, has not found a single fragment of Pyrotherium, though Ameghino says that Pyrotherium is the most abundant and most characteristic fossil in the beds. Dr. Roth found other fossils of the Pyrotherium fauna fairly abundant.

The Pyrotherium beds, as that term has been used by Dr. Ameghino, includes a series of deposits of varying age from Eocene to Pleistocene. These deposits are of limited area and usually appear as yellow or ochre-colored sands and clays filling depressions eroded in the surface of the Guaranitic beds or occasionally of the Lower Lignites and Variegated Sandstones. The stratigraphic relations of these various Tertiary deposits to the Dinosaur and other Cretaceous beds of Patagonia are the same as the relations of the Equus to the Loup Fork and other Tertiary beds in our western States; and these somewhat obscure stratigraphic relations have led to the same confusion regarding the age and fauna of each that formerly existed concerning those of the Equus and Loup Fork beds.

Toward the close of the Eocene there began over southern Patagonia a period of subsidence, sufficient to bring most of that region beneath the surface of a shallow sea. Land areas continued to exist, however, along the Andes and an important land mass also extended over what is now the central interior plains region, to the eastward of Lakes Pueyrredon and Buenos Ayres. This land mass was perhaps connected with the continental land mass to the northward. From the commencement of this late Eocene subsidence until the middle of the Miocene, marine conditions, more or less extensive, prevailed continuously over portions of this region. Such marine conditions would progress or recede as the rate of subsidence exceeded, equalled or fell below the rate of sedimentation constantly going on over the bottom, and thus there was laid down over this region a series of deposits of marine and freshwater or aëolian origin, frequently interstratified, especially about the shores of the land masses. Such marine deposits are characterized everywhere by abundant remains of marine invertebrates of shallow water forms; while the lacustrine and aëolian deposits, though less rich in fossil remains, contain the bones and teeth of the animals inhabiting the lands adjacent to or over which they were deposited.

Eocene and Oligocene.

Magellanian Series.—This late Eocene subsidence commenced over the southern regions and gradually extended northward. In the vicinity of Punta Arenas there are represented several hundred feet of marine Tertiary deposits containing a marine fauna quite distinct and of decidedly older age than any of the marine Tertiary deposits known from the Atlantic coast region farther north. These marine deposits have been named by Dr. Ortmann the *Magellanian beds* and a brief description has been given by that author of the various species of marine invertebrates collected in them by the writer.

The type locality for the *Magellanian beds* may be considered to be the bluffs of the Rio de las Minas (Mines River on the map) that flows through the town of Punta Arenas and empties into the Strait of Magellan. These beds are especially well represented and extensively exposed on the left bank of that stream from the coal mines located about five miles above the town to a point some three miles lower down where the stream emerges from the cañon onto the level plain that extends from the foot of the hills to the beach north of the town. The Rio de las Minas has its source in the low range of mountains or hills separating the Magellan Strait from

Otway Water and forming the northern portion of the Brunswick peninsula, the southernmost point of the mainland of South America. The river has a nearly east and west course, and throughout its entire length the bluffs on either side of the stream are composed of sedimentary deposits of varying age from Upper Eocene to Pliocene, excepting certain bowlder deposits on the top of the mountains and other loess deposits in the valley, both of which are unfossiliferous and evidently of Pleistocene age.

Ascending the river from Punta Arenas, the Magellanian beds are first seen just where the stream emerges from the mountains about two miles above the town. At a short distance above this point a more important exposure may be seen on the left bank of the stream where the axis of a very gentle anticline is passed. From the axis of this anticline the strata on one side dip gently to the eastward or down stream and soon successively disappear beneath the bed of the stream, while on the other side they dip to the westward or up stream at an angle of perhaps five degrees. This westward inclination of the strata is continuous from the axis of the anticline to the source of the river except where affected by some local fault or landslide, as frequently happens above the coal mines and therefore in the beds above the Magellanian beds. No such faults were observed in the Magellanian beds below the mines.

In the bluff at the anticline, a few feet above the bed of the stream, there is a layer with numerous flattened concretions frequently a foot or two in diameter and of a light gray color, with fairly abundant leaf impressions, belonging principally to the genus *Fagus.* Some fifty feet higher up in the bluff another concretionary layer is encountered containing in great abundance the remains of marine invertebrates. In ascending the river some two or three miles until the coal mines are reached, several hundred feet of strata are passed through containing numerous fossil-bearing layers. Two such layers, each about ten or twenty feet thick, are especially prominent, appearing as bold projecting ledges due to the harder nature of the rocks composing them, and made up largely of the shells of various species of mollusca.

Dr. A. E. Ortmann, who has studied the invertebrate collections from these beds, has decided that they are not only quite distinct from the faunas of the *Patagonian* and *Supra-Patagonian beds* of the Atlantic coast farther north, but also that they differ entirely from the invertebrate faunas of the marine beds overlying the coal beds at this locality. He considers the fauna of the *Magellanian beds* as indicative of a decidedly greater age for these beds than should be accorded to the *Pata-*

gonian beds; he therefore considers the *Magellanian beds* as of *Late Eocene* or *Early Oligocene* age. I may also add that this paleontological evidence as to the age and position of the Magellanian beds is fully supported by stratigraphic evidences, since the same Coal Measures found at Punta Arenas have been observed farther north underlying beds that contain a fauna characteristic of the Patagonian beds. Moreover the beds which at Punta Arenas overlie the Coal Measures contain a fauna essentially characteristic of the Patagonian beds farther north.

The Magellanian beds at Punta Arenas are represented in the bluffs of the stream by perhaps 1,000 feet of strata, and the core from a hole sunk by a diamond drill to a depth of 360 feet in the bottom of the valley opposite the anticline already mentioned, did not pass through them. At present these beds have not been observed elsewhere than at the Punta Arenas locality. Very similar deposits were observed underlying certain lignites about the headwaters of the south fork of the Rio Chico, but it was not possible to secure other than fragmentary fossils from them. It is quite probable also that certain marine beds mentioned by Ameghino as occurring near Lake Argentina and about the source of the Rio Shehuen belong to the Magellanian beds. It may also be found advisable to correlate certain horizons in Dr. Ameghino's *Pyrotherium beds* with the Magellanian as representing lacustrine or aëolian deposits contemporaneous in origin with the marine beds farther south. In the excellent section of the Rio Tarde Cañon near Lake Pueyrredon the Magellanian beds and the overlying lignites are entirely wanting.

Upper Lignite beds.—In the Rio de las Minas section the Magellanian beds are conformably overlaid by a series of strata of unknown vertical extent, containing several veins of almost pure lignite varying from a few inches to ten or twelve feet in thickness. These beds, which constitute the upper limits of the *Magellanian Series*, have been observed at various places along the eastern Andes from Punta Arenas to the head of the Rio Chico north of Lake San Martin. They are probably of Middle or Upper Oligocene age.

Oligocene and Miocene.

Patagonian Series.—Under this head I shall include those deposits which have been commonly referred to by students of the geology of Patagonia under the names of *Patagonian, Supra-Patagonian* and *Santa Cruz beds.* On account of the fossils found in them and their great surface distribution throughout southern Patagonia, they are the most important of all the sedimentary rocks of this region.

Patagonian beds.—The type locality for the Patagonian beds may be considered as the bluffs of the Atlantic coast from Port Desire southward to the Mt. of Observation, some forty miles south of the Santa Cruz River. Anywhere along this coast within these limits the Patagonian beds may be found well represented and rich in the remains of fossil invertebrates. They appear to attain their maximum development in the region of San Julian, where they show a thickness above the water level of about 900 feet. From this point they dip gently to the southeast, so that at Coy Inlet their uppermost strata pass beneath the water level. The Patagonian beds are also known to extend along the Atlantic coast for a considerable distance north of Port Desire, and are found exposed in many localities in the bluffs of the streams throughout the interior of all that portion of southern Patagonia lying north of the Santa Cruz River. They may also be seen in a series of outcrops extending all along the eastern base of the Andes. In the section of the Rio de las Minas, they conformably overlie the Upper Lignites. They also appear in the bluffs near Lakes Argentina, Viedma and San Martin, at Shell Gap and various other places on the head of the Rio Chico and in the Pueyrredon and Rio Tarde sections, where they are 700 feet thick and rest directly upon the Variegated Sandstones or are separated from the latter by about fifty feet of columnar basalt. The entire series of strata constituting the Lower Lignites, Guaranitic and Magellanian beds and the Upper Lignites are wanting in the Pueyrredon region.

Ameghino has always considered the Patagonian and Supra-Patagonian beds as distinct and separated by a considerable period of time, and in my former paper I took the same view, since at that time I had worked but little in the typical *Patagonian beds.* During the last two years, however, I have given considerable attention to a study of the Patagonian beds in the type localities, and have made extensive collections of vertebrate and invertebrate fossils from them at Port San Julian and Darwin Station, some twenty miles south of that port, and about the mouth of the Santa Cruz River and the Mt. of Observation farther south on the Atlantic coast. These collections from the typical Patagonian beds I have also supplemented by collections made at many different localities throughout the interior region, and representing every conceivable horizon from the base to the top of the so-called Supra-Patagonian beds of that region, as well as at the Mt. of Observation. Among the localities from which such collections were made I may mention the following: the bluffs of the Santa Cruz River, source of Rio Shehuen, several localities between the latter stream and the Rio Chico, at Sierra Oveja

and Shell Gap and other places on the Rio Chico, Lake Pueyrredon, about the sources of Desire River, and at various places in the valley of San Julian. A study of the collections made at all of these and various other localities, with a careful regard for the different horizons from which the various collections were made, has demonstrated beyond a reasonable doubt the identity of the *Patagonian and Supra-Patagonian beds*, which do not represent distinct series of deposits of different age, but only different phases of the same series of strata. The differences in the fossils and lithological characters are in each instance due to the local conditions attending the deposition of the beds at the various localities in which they were found. The Patagonian beds represent areas covered by deeper waters, while the Supra-Patagonian beds represent the shallow water and littoral deposits. In the former the strata are more continuous and the rocks composing them are of a finer grain and with usually more calcareous material, while in the Supra-Patagonian phase the strata of sandstones, clays, etc. replace one another at frequent intervals along the same horizon, and are largely composed of coarse sands mingled with broken and ground fragments of shells in great abundance, frequently forming a genuine shell breccia.

Dr. Ameghino, in his latest contribution on the geology of this region, has not only separated the Supra-Patagonian beds from the Patagonian beds, but has also divided the latter into two formations, a lower *Piso Juliense* and an upper *Piso Leonense.* He thus has represented three distinct formations, which beginning below are called the *Juliense*, *Leonense* and *Superpatagonica.* Under each of these he gives a list of characteristic invertebrates as follows:

Piso Juliense.—Terebratula patagonica=(Terebratella p.). Bouchardia Zitteli, Rhynchonella plicigera = (R. nigricans), Pecten geminatus, Pecten praenuncius, Siphonalia noachina, Hypechinus patagonicus, Echinarachinus juliensis, Schizaster ameghinoi.

Piso Leonense.—Ostrea percrassa = (O. ingens), Perna quadrisulcata, Cucullæa alta, Turritella argentina, Struthiolaria ornata.

Superpatagonica.—Ostrea patagonica = (ingens, non d'Orb.), Pecten quemadensis = (P. geminatus), Cytherea splendida, Amathusia angulata, Voluta ameghinoi, Dentalium octocostatum.

Dr. Ortmann, who has studied our collections of Tertiary invertebrates from Patagonia and finds represented in them, with but one or two exceptions, every species hitherto reported from that region besides many additional ones, has made for me the following lists, showing the association which he has

already found to exist among species given by Dr. Ameghino as characteristic of the different beds, which that author has considered as distinct.

Among the collections from San Julian, the type locality for the Piso Juliense, he finds at Oven Point all the Juliense species but two (*Pecten prænuncius* and *Hypechinus patagonicus*) mingled with *Ostrea ingens*, a Leonense and Suprapatagonica species, while at Darwin Station, a higher horizon, these Juliense species are found: *Terebratella patagonica, Pecten geminatus, Siphonalia noachina.*

At the mouth of the Santa Cruz River, there are found mingled together in the same horizon all the species given by Ameghino as characteristic of his *Piso Leonense*, together with the following Juliense species: *Terebratella patagonica, Pecten geminatus, Schizaster ameghinoi* and these Supra-Patagonian forms: *Ostrea ingens, Amathusia angulata, Dentalium octocostatum.*

From the Mt. of Observation we have in the lowermost horizon *Cucullæa alta*, a Leonense species, while in the upper horizon or Supra-Patagonian beds, there are *Terebratella patagonica* and *Siphonalia noachina*, Juliense species, mingled with *Ostrea ingens*, a Leonense and Supra-Patagonian species, and *Voluta ameghinoi* and *Dentalium octocostatum*, Supra-Patagonian species.

At the base of the marine Tertiary in the Lake Pueyrredon section, which according to Ameghino should be Supra-Patagonian beds, we have the following five Juliense species, *Terebratella patagonica, Bouchardia Zittelli, Rhynchonella nigricans, Pecten geminatus, Echinarachinus juliense* and *Perna quadrisulcata*, a Leonense species, together with *Ostrea ingens*, a Leonense and Supra-Patagonian species.

In the uppermost of the Supra-Patagonian beds on the upper Rio Chalia and at Shell Gap or Rio Chico, the following three Juliense species, *Terebratella patagonica, Rhynchonella nigricans, Echinarachinus juliensis*, occur associated with *Turritella argentina*, a Leonense species, and *Ostrea ingens*, from the Leonense and Supra-Patagonian beds.

In one small block six inches in diameter, from the mouth of the Santa Cruz River, *Terebratella patagonica* and *Pecten geminatus*, Juliense species, were found associated with *Struthiolaria ornata*, which according to Ameghino is characteristic of the Piso Leonense.

In the above lists it will be noticed that only the characteristic species as given by Ameghino are included and it is seen that in every instance there has been found a mingling in the same horizon of these supposedly characteristic forms. While in some instances, as at Lake Pueyrredon, upper Rio Chalia

and Shell Gap, which according to Ameghino should be Supra-Patagonian beds, there is a preponderance of species given by him as characteristic of the Piso Juliense at the base of the Patagonian beds.

From a consideration of these facts regarding the association of fossils, it is clear that the terms *Piso Juliense* and *Piso Leonense* cannot be accepted, and also that the *Patagonian* and *Supra-Patagonian beds* are not distinct formations, but simply represent different phases of one and the same formation. The Patagonian phase prevails at the base of the series and the Supra-Patagonian at the top, but neither is limited to any definite horizon. I therefore discard the term Supra-Patagonian beds, and shall refer to strata formerly known under that name as the Supra-Patagonian phase of the Patagonian beds.

Age of the Patagonian beds.—Concerning the age of the Patagonian beds, there has been much difference of opinion. This difference has been due largely to careless collecting and imperfect observations as to their true stratigraphic position. During the first five years of their work on Patagonian geology and paleontology, the Ameghinos considered the *Patagonian beds* as overlying the *Santa Cruz beds.* They then placed the so-called Supra-Patagonian beds not only beneath the Patagonian beds, but separated from them by the entire series of strata composing the Santa Cruz beds. At that time they called the *Supra-Patagonian beds* the *Sub-Patagonian beds*, and the sequence as then determined by the Ameghinos in Patagonia was beginning below the *Sub-Patagonian beds*, the *Santa Cruz beds* and the *Patagonian beds.* In 1893, Senor Alcides Mercerat visited Patagonia and determined the true stratigraphic relations of these deposits, which he found to be identical with those suggested by Darwin a half century earlier. In 1894, in his fifth year of field work in Patagonia, Senor Carlos Ameghino, following Mercerat, was able to confirm the latter's determinations concerning the relative positions of these various formations, and the 2,500 feet of strata composing them were forthwith turned upside down, so to speak, by Dr. Ameghino, the Patagonian beds being placed at the base of the series instead of at the top and the Supra-Patagonian beds were removed from the bottom to the middle of the series and the sequence changed to *Patagonian*, *Supra-Patagonian* and *Santa Cruz beds*, passing from beneath upwards. This remarkable bit of stratigraphic juggling was accomplished in such a skillful manner by Dr. Ameghino that it became unnecessary for him to make any considerable changes in the age of the various beds to accommodate and harmonize with their altered and true stratigraphic relations. To

this discrepancy on the part of Dr. Ameghino is largely due the conflicting opinions at present expressed by him concerning the age of these various deposits.

The Patagonian beds are here placed in the Upper Oligocene and Lower Miocene on account of the evidences afforded by the marine invertebrates found in them. Moericke, Steinmann, Cossmann, Dall and others, all of whom have studied more or less material from these beds, are agreed in placing them in the Miocene. Dr. A. E. Ortmann, who is studying our collections in which there is represented much the most complete series yet brought together from the Tertiaries of Patagonia, is convinced that they are not older than uppermost Oligocene, and that they are chiefly Miocene. Dr. von Ihering, who studied the collections of Carlos Ameghino, relying upon his and Dr. Ameghino's stratigraphic determinations and differentiations, which as has been shown are only local developments and do not represent distinct horizons, has referred the Patagonian beds to the Upper Eocene and the so-called Supra-Patagonian beds to the Oligocene and Lower Miocene. Dr. Ameghino has himself considered the Patagonian beds as belonging to the Upper Cretaceous and Lower Eocene, assigning them this position, apparently, in order to accommodate his theory concerning the great antiquity of the overlying Santa Cruz beds.

In connection with the age of the Patagonian beds it is interesting to note the remarkably close relationship existing between this invertebrate fauna and the invertebrates from the Oamarú and Pareora Systems of New Zealand, which latter, according to Hutton, belong respectively to the Oligocene and Miocene. Dr. Ortmann has already found the following twelve identical species: *Rhynchonella squamosa* Hutt. (=costata Ten. Wood = pyxidata Dav.), *R. nigricans* (Sow.) (=plicigera v. Ihr.), *Magellania lenticularis* (Desh.) (=globosa v. Ihr), *Terebratella dorsata* (Gmel.), *Terebratella patagonica* (Sow.), *Ostrea ingens* Zitt. (=patagonica Aut. non d'Orb.= percrassa v. Ihr.=hàtcheri and phillippi Ortm.), *Cucullæa alta* Sow., *Limopsis insolita* (Sow.), *Dentalium giganteum* Sow., *Scalaria rugulosa* Sow. (=lyrata and browni Zitt.), *Crepidula gregaria* Sow. (=incurva Zitt.), *Natica solida* Sow., and he informs me that this list will be very much increased and that many other species, while not precisely identical, show remarkably close relationships. The affinities exhibited by these two faunas are of interest not only for the evidence they afford concerning the age of the Patagonian beds, but also on account of the additional proof they furnish in favor of the theory of a former land, or at least exceedingly shallow sea, connecting New Zealand and other austral lands with South America.

The Santa Cruz beds.—Immediately and conformably overlying the Patagonian beds are the Santa Cruz beds, composed of a series of usually soft and light-colored sandstones and shales, rich in the remains of birds and mammals, but for the most part remarkably destitute of any molluscan or other invertebrate fossils, in marked contrast with the underlying beds. At the base the Santa Cruz beds are sometimes interstratified with the uppermost Patagonian beds. This condition was first recognized and pointed out by the Ameghinos. On my first expedition to Patagonia I was unable to find any conclusive evidence of such interstratification, and from certain apparent unconformities noticed at Shell Gap and Sierra Oveja on the Rio Chico, I concluded that the Santa Cruz beds were not interstratified with the Patagonian beds but were separated from them by a considerable time interval. Subsequent explorations have, however, convinced me of my error and I have been able to verify the observations of Señor Carlos Ameghino at the Mt. of Observation and to make similar observations in the Lake Pueyrredon section and at other localities throughout the interior.

The Santa Cruz beds are first seen in the Atlantic coast section near Mt. Observation south of the Santa Cruz River, where they form the summits of the higher bluffs bordering the coast. From this point southward they form a constantly increasing proportion of the total thickness of the bluffs of the sea until, on the south side of Coy Inlet, the entire series of strata forming the bluffs, with a maximum thickness of 600 feet, are composed of rocks of the Santa Cruz beds, which extend uninterruptedly to the mouth of the Gallegos River. It will thus be seen that the Santa Cruz beds appear continuously in the bluffs of the Atlantic coast from Cape Fairweather north for a distance of about 100 miles. They also cover the entire plains region between this coast line and the Andes, and toward the west they stretch far to the northward, extending even as far as the latitude of Lake Buenos Ayres, or 46° 30′ S.

The maximum development so far observed in the Santa Cruz beds may be seen in the Lake Pueyrredon and Rio Tarde section, where they overlie the Patagonian beds and show a thickness of 1,500 feet. From Lake Pueyrredon the Santa Cruz beds may be traced in an almost unbroken series of outcrops extending for more than 300 miles along the eastern range of the Andes.

From the entirely different character of the fossils encountered it is evident that there was a considerable change in the physical features of this region during the period which marked the close of the deposition of the Patagonian beds and

the beginning of the deposition of the Santa Cruz beds. About this time the gradual subsidence which had been going on during the deposition of the former series, became less rapid or ceased altogether, and the shallow sea in which those rocks were being deposited was converted into lowlands and estuaries which were at once invaded by the herds of animals inhabiting the adjacent lands, or others more distant, with which communications were then established. The remarkably rich mammalian fauna that at that time inhabited this region has left its remains in great abundance and often in a remarkably good state of preservation in the sandstones and clays of the Santa Cruz beds. Scarcely a foot of this entire 1,500 feet of sediment that is not fossiliferous, and seldom an exposure, however small in area, that will not yield a jaw or skull as a reward for even a superficial search. It is not to be understood that these deposits are everywhere equally rich in fossils, for like all other fossil fields, some localities are rich and some poor according as were the conditions during the deposition of the sediment favorable or not for the accumulation and preservation of animal remains.

Nothwithstanding the remarkable similarity of the rocks forming the Santa Cruz beds in the many exposures throughout their great geographical extent, it is evident that they were not deposited in an open fresh-water lake nor in a broad shallow sea of salt water. Not only are they in their typical development remarkably barren of the remains of either fresh or salt water invertebrates, but they contain the remains of land mammals in such abundance that it is absolutely impossible to conceive of these remains having been conveyed bodily into the middle of a great lake or ocean hundreds of miles in breadth. So far as is at present known, not a single mollusk shell, or fish, or crocodile bone or tooth has been found anywhere in the true Santa Cruz beds; although many of the strata are well adapted for the preservation of the remains of such animals, had they existed in any considerable numbers, as would undoubtedly have been the case had this region been covered during the period of their deposition by a great lake or other continuous body of water. Not only are the remains of land mammals abundant in many exposures, but in some instances the positions in which the skeletons are found are such as suggest that the animals lived and died in the immediate neighborhood where their remains now lie entombed.

One of the best localities for the collector of vertebrate fossils to be found anywhere in Patagonia is on the beach laid bare at low tide along the Atlantic coast between Coy Inlet and Cape Fairweather. On this beach the erosion accomplished by the rise and fall of the tides, which here have a maximum

difference of 46 feet, takes place along the bedding plains. Thus the same stratum frequently forms the surface over considerable areas, and the present slope of the beach is often for considerable distances precisely that of the inclination of the beds. Consequently in this region when a particularly rich fossiliferous horizon is found in the bluff, it will appear at its proper place on the beach owing to the southeasterly dip of the beds, and will form the surface over a considerable area often two or three miles in extent, each bedding plane appearing successively as the present surface of the beach, exposed to view only at low tide. When such localities were met with they were found to be extremely rich in fossils, and it was frequently possible while standing in one position to count a dozen or more skeletons, varying in completeness according as they had been more or less uncovered and washed away by the tides. Not only were the skeletons of these animals to be found, but in several places their fossil footprints were observed, and owing to the peculiarly favorable erosive action which prevails here, series of such footprints were occasionally seen extending for upwards of 100 feet, each track distinctly impressed so that it would have been possible to count the number of steps taken in covering a given distance and to measure the exact stride of the animal. All these conditions taken together bear conclusive evidence, it seems to me, that the skeletons belong to the same animals that made the footprints and therefore that these animals inhabited this very region during the time when the sediments now forming the rocks were being accumulated in the bottoms and over the flood plains of the swamps, small lakes, and tributary streams which existed here. Periodical variations in the amount of moisture, together with other conditions, would perhaps account for the lack of invertebrate remains.

Since the Santa Cruz beds conformably overlie the Patagonian beds, which have been shown to belong to the Upper Oligocene and Lower Miocene, the Santa Cruz beds must therefore belong to the Middle and Upper Miocene. This stratigraphical evidence of the age of these beds is strongly supported by the paleontological evidences afforded by the mammalian remains found in them. The highly specialized character of most of the genera can hardly be taken to indicate a greater antiquity for any of the strata than Middle Miocene.

Cape Fairweather beds.—The close of the Miocene was marked by a general subsidence, so that the sea again had access to this region, and during Pliocene times marine conditions prevailed here, resulting in the deposition of a series of deposits with a marine invertebrate fauna which originally covered almost the entire region, but has since been mostly removed and now appears over limited and widely separated areas, rest-

ing alike upon the rocks of the Patagonian and Santa Cruz beds or as has been occasionally observed upon some of the older basalts of the interior region.

The typical locality for the Cape Fairweather beds is near Cape Fairweather, where they may be seen at a distance of about two miles north of the Gallegos River, near the summit of the bluffs, unconformably overlying the Santa Cruz beds. They have also been observed near Darwin Station, south of San Julian, where they rest unconformably upon the Patagonian beds. They attain their maximum development in the region of Lake Pueyrredon, where they form the upper 300 feet of two isolated buttes on the top of the high bluff just south of the east end of the lake. At this locality they lie with apparent conformity upon the Santa Cruz beds, and the sedimentation appears to have been continuous at this place, at least, from the one to the other series.

Drs. H. A. Pilsbry and A. E. Ortmann, both of whom have studied our collections of invertebrates from these beds, are agreed as to their Pliocene age, which is moreover in strict accord with their stratigraphic position in relation to the Santa Cruz beds.

Distributed over almost the entire surface of the Patagonian plains and resting unconformably upon the various sedimentary deposits mentioned above, is the great *Shingle formation* of Pleistocene age and of combined ice and aqueous origin.

The following table is intended to show the sequence of the various sedimentary rocks of Patagonia and their age as at present indicated by paleontologic and stratigraphic evidences.

Pleistocene.	Shingle formation.
Pliocene.	Cape Fairweather beds.
Miocene.	Santa Cruz beds.
Oligocene.	Patagonian beds.
	Upper Lignites.
Eocene.	Magellanian beds.
	Wanting.
Cretaceous.	Guaranitic beds.
	Lower Lignites.
	Variegated Sandstones.
	Upper Conglomerates.
	Belgrano beds.
	Lower Conglomerates.
	Gio beds.
	Wanting.
Jurassic ?	Mayer River Shales.

Princeton, N. J., December 26, 1899.

Art. IX.—*Explorations of the "Albatross" in the Pacific.* II. *The Paumotus;* by Alexander Agassiz.

[*Letter No. 2*, dated Papeete Harbor, Tahiti Island, November 6, 1899, to Hon. Geooge M. Bowers, U. S. Commissioner of Fish and Fisheries, Washington, D. C., by Alexander Agassiz.]

During our stay in Papeete some time was spent in examining that part of the barrier reef of Tahiti which had been surveyed by the Challenger. We found the condition of the outer slope of the reef quite different from its description as given in the Challenger narrative. The growing corals were comparatively few in number, and the outer slope showed nothing but a mass of dead corals and dead coral bowlders beyond 16 or 17 fathoms, few living corals being observed beyond 10 to 12 fathoms.

We also made an expedition to Point Venus, to determine, if possible, the rate of growth of the corals on Dolphin Bank from the marks which had been placed on Point Venus by Wilkes, in 1839, and by MM. Le Clerk and de Bénazé, of the French navy, in 1869. We found the stones and marks as described, but in view of the nature and condition of Dolphin Bank, did not think it worth while to make a careful survey, as Captain Moser had intended to do. On examining Dolphin Bank in the steam launch I was greatly surprised to find that there were but few corals growing on it. I could see nothing but sparsely scattered heads, none larger than my fist! the top of the bank being entirely covered by Nullipores. We sounded across the bank in all possible directions and examined it thoroughly, and at the stage of water at which we sounded, found about 18 inches difference from the soundings indicated by the charts. It is also greatly to be regretted that Dolphin Bank was not examined, neither in 1839 nor in 1869, and notes made of what species of corals, if any, were growing on its surface; for an excellent opportunity has been lost to determine the growth of corals during a period of 60 years. The choice of this bank as a standard to determine the growth of corals was unfortunate, as it is in the midst of an area comparatively free from corals.

After refitting and coaling here, we left on the 5th October for a cruise in the Paumotus.

We steamed for Makatea, which we had visited on our way to Tahiti, and not only examined the island more in detail, but took a number of photographs of the cliffs of the east side, which, on our first trip, we passed late in the afternoon. We crossed the island from west to east, the path leading down from the summit of the cliffs bordering the island into a sink

at least 40 to 50 feet lower than the rim of either face of the island. The sink occupies a little more than one-third the length of the island. It is deeper at its southern extremity, where it is said to be 75 to 100 feet below the rim of the adjoining cliffs.

It is difficult to determine if this sink is the remnant of the former lagoon of the island, or of a sound formed during its elevation; or if it has been formed by the action of rain and atmospheric agencies. The amount of denudation and erosion to which this island has been subjected is very great, as is clearly indicated by the small cañons, pinnacles, and walls of limestone, as well as by the crevasses which occur in the surface of the basin in all directions. The extent to which this action has penetrated into the mass of the island is also plainly shown by the great number of caverns which crop out at all levels along the sea face of the cliffs, some of which are of great height, and extend as long galleries into the interior of the island. It is, of course, difficult, in the face of this extensive denudation and erosion, to state positively what may be part of the ancient lagoon, or sound, and what has been carried away by atmospheric and other agencies since the elevation of the island. At the south end of the island, which is lower than the northern part, there are only two distinct terraces, while at the northern end four terraces can be traced. The southern extremity, however, is still higher than the deepest part of the central sink of the island.

From Makatea, we visited Niau, Apataki, Tikei, Fakarava, Anaa, Tahanea, Raroia, Takume, Makemo, Tekokota, Hikueru, Marokau, Hao, Aki-Aki, Nukutavake, going as far east as Pinaki, when we turned westward again, to Nukutipipi.

On arriving at Pinaki we decided to give up the exploration of the eastern extremity of the Paumotus, and not to make our contemplated visit to the Gambier Islands, our time having been greatly curtailed by delays at Fakarava and Makemo, from bad weather and the non-arrival of our coal supply. We therefore reluctantly turned westward again and made for the Gloucester Islands. These, as well as Hereheretue, proved most interesting; they formed, as it were, an epitome of what we had seen on a gigantic scale in the larger atolls of the western and central Paumotus. We could see at a glance in such small atolls as Nukutipipi and Anu-Anurunga the connection between structural features which, in an atoll of 40 miles in length and from 10 to 15 miles in width, it was often difficult to determine.

We anchored in Fakarava and Makemo Lagoons, spending a number of days in both these atolls. We usually timed our visits to the islands where we could not anchor so as to spend

the day, or the greater part of the day, at these atolls, making our passages at night, and sounding whenever practicable on the way.

After leaving Tahiti we made over 100 soundings. These have shown in a general way that the western islands are probably all on a great plateau connected perhaps by the 800-fathom line. That such islands as Anaa are probably on spurs or independent smaller plateaux, separated from the main plateau by somewhat deeper water; the same may be the condition of Raroia and Takume, and of Hao and Amanu, while such smaller and isolated islands as Tikei, Aki-Aki, Nukutavake, and Pinaki, as well as the Gloucester islands, rise from greater depths and are isolated peaks. At any rate, these soundings indicate, as do the soundings off the Fijis, that atolls do not necessarily rise from very great depths, and that in this characteristic atoll district, atolls are found, it is true, with steep slopes, but rising from moderate depths. The slopes of these atolls would probably resemble in every respect the slopes of the elevated coralliferous limestone islands characteristic of the Lau Group in Fiji.

The deepest sounding among the Paumotus was on the line to the northward of Hereheretue in the direction of Mehetia, where we found a depth of 2524 fathoms, and a continuation of the red clay characterizing the soundings since we left Pinaki. In nearly all the soundings among the Paumotus, even at moderate depths not far from the atolls, we brought up manganese particles or small manganese nodules. The last haul, made in deep water on the way from Hereheretue, in 2440 fathoms, brought at least half a ton of manganese nodules, the bottom being red clay.

We have now steamed about 2500 miles among the Paumotus, and although we had not the advantage of the accurate surveys of the English Hydrographic charts, which made the exploration of Fiji so easy, yet from the structure of these atolls it was a comparatively simple task, by steaming around the islands and landing wherever practicable, to get a fairly good idea of their structure. We have seen nothing in this more extended examination of the group tending to show that there has anywhere been subsidence. On the contrary, the condition of the islands of the Paumotus cannot, it seems to me, be explained on any other theory except that they have been formed in an area of elevation; an area of elevation extending from Matahiva on the west to Pinaki in the east, and from the Gloucester islands on the south to Tikei on the north, although the islands in the line of Mangareva to Tahiti are separated from the other Paumotus by a deep channel, nearly 200 miles wide and more than 2400 fathoms in depth,

with scattered islets and atolls extending from Mangareva to Pinaki, and northward to Serle Island and beyond, islands which are not connected with the extensive plateau upon which the greater number of the Paumotu Islands to the westward of Hao rise.

All the islands we have examined are, without exception, formed of Tertiary coralliferous limestone which has been elevated to a greater or less extent above the level of the sea, and then planed down by atmospheric agencies and submarine erosion, the greatest elevation being at Makatea (about 230 feet), and at Niau, where the Tertiary coralliferous limestone does not rise to a greater height than 20 feet. At Rairoa it was 15 to 16 feet high. At other islands it could be traced only as forming the shore platform, from 50 to 150 feet wide, which forms the outer face of the Paumotus and is so characteristic a feature of the atolls of the group. In other parts the old ledge could be traced cropping up in the interior of the outer rim, or in the open cuts connecting the lagoon with the outer sea face of the atolls. Everywhere the space between the outcropping of the old ledge, as I will call the Tertiary coralliferous limestone, was filled with beach rock, or a pudding-stone, or with a breccia or conglomerate of coralliferous material consisting in part of fragments of the old ledge, and of fragments of recent corals and shells cemented together.

The appearance of the old ledge and of the modern reef rock is so strikingly different that it is very simple to distinguish the two, even where only comparatively small fragments are found.

We did not find in the Paumotus, as in Fiji, all possible stages of denudation and of submarine erosion between islands like Vatu Vara, Niau, Kambara, Fulanga, Ongea, Oneata, Ngele Levu, and Weilangilala, and atolls with a mere ring of surf to indicate their existence.

In the Paumotus the islands have been elevated to a very moderate height and probably to nearly the same height, for the old ledge forming the base of the modern structure is found exposed nearly everywhere at about low-water when it cannot be traced at a slightly greater elevation. This would readily account for the nearly uniform height of the islands throughout the group.

But there is another element which comes into play in this group, and has an important part in shaping the ultimate condition of these atolls. At the Fijis we have seen the submarine erosion continue until there is little left of many of the atolls beyond the merest small islet or rock to indicate its structure. In the Paumotus, in the great atolls which are evidently only the exposed summits of parts of ridges or spurs of an

extensive Tertiary coralliferous limestone bed, the rim of the atoll is, after having been denuded to the level of the sea, again built up from the material of its two faces, which is thrown up on the wide reef flats both from the sea face and from the lagoon side. We do not find in the Fijis such huge reef shelves to supply such masses of material from the breaking up of the outer and inner edges of the Tertiary limestone platforms, in addition to the fragments of the recent corals growing upon the flat and its edges, which, when dead, are thrown up and formed into shingle and sand to form a pudding-stone, or a conglomerate, or breccia, with the fragments of the old ledge on the top of the reef flats.

This pudding-stone, or beach rock, is found on all the reef flats of the islands of the group. It forms great bars, at right angles usually to the shore-line, and upon the sea face of these bars is thrown up coral shingle, both old and recent, which builds up short reaches of beaches separated by wide flats through which the sea rushes at high-water, or merely covers the flats at low tide; while on the lagoon side of the wide reef flats a similar process is going on, throwing up finer sand among the beach-rock bars and along their sides, and thus building up little by little; at first small sand bars, then larger bars, or islets, at right angles to the shore-line, and as they become larger by accretions from both sides, they finally form an island from 1,000 to 1,200 feet long, according to the width of the reef flat, extending from the lagoon edge of the flat to the sea face of the atoll. The sand bars, little by little, become covered with vegetation, and at some stages of tide appear like islands and islets situated a considerable distance within the lagoon. Whenever the material supplied both from the lagoon side and from the sea face is very abundant, the land ring becomes more or less solid, the islets become consolidated into islands, separated by narrow or wider cuts, until finally they form the larger islands which seem at first glance to form continuous land along the rim of the lagoon, but which are often seen to be separated according to local conditions by narrow cuts which finally allow no water to pass through and merely indicate the former separation of the various parts of the land.

In the lagoons of atolls of such great length as some of these of the Paumotus, like Rairoa, Fakarava, Makemo, and Hao—which are between 30 and 40 miles long, and others of less dimensions, considerable sea rises under the prevailing trades. The sea and wind generally follow the trend of the shores, both in the lagoon and along the sea face, so that the bars of beach rock act like buttresses and collect material at their inner and outer extremities, forming the sand bars and islets which eventually become the land rim of the lagoon.

When the material is not, from local causes, very abundant, or is washed out over the flats, there are fewer islands, and often these are but mere islets or bars for long reaches of shore, forming the characteristic weather faces of many of the lagoons.

Many of the lagoons are filled with shoals or ledges awash or a few feet above the sea level. These shoals are parts of the old ledge which have not as yet been eroded, and the disintegration of which has gone far to supply the material for the land of the outer rims of the atolls. In Fakarava there were no less than 36 islands and islets and ledges, parts of a former great flat, now broken up, existing parallel to the outer reef flat about 4 miles in the lagoon. Similar reef flats exist in Tahanea, where they form a secondary lagoon with 2 to 3 fathoms of water, extending nearly the whole length of the western face of the atoll. There are several large islands on this flat and at high water they would appear as the islands and islets of Fakarava do, as disconnected and planted in the lagoon itself. A secondary lagoon also exists in Ravahere, and in Anaa; in both these atolls the reef flat extends across one extremity of the lagoon and does not run parallel to the longer shore-line of the atoll.

The lagoons of these atolls have a general depth of 13 to 20 fathoms. In some cases they are somewhat deeper, as is stated, but there are no measurements, the greater depths, 30 fathoms or more, being due to orogenic conditions. Some of the atolls are quite shallow, as at Matahiva, as well as Pinaki, where the lagoon is not more than 2 to 3 fathoms, and Takume, where it is from 5 to 6 fathoms deep. Some of the smaller islets we visited, among which are Tikei, Aki-Aki, and Nukutavake, have no lagoons. The former has a small shallow sink in which fresh water collects, but the rim is only very slightly higher than the interior. The last two islets are apparently depressed in the center, 3 to 4 feet below the outer bank of sand which forms the rim (about 10 to 12 feet high) of the basin of the island. I was at first inclined to look upon these islands as examples of islands which had been cut down to the level of the sea and subsequently been built up by beach rock and sand in the manner described above. The existence of extensive sand dunes on two sides of the island at Pinaki, and of a large dune (estimated to be 35 feet high) on the south shore of Nikutavake, seems to indicate the possibility of there having been a shallow lagoon occupying the center of Aki-Aki and of Nukutavake, and that these lagoons were gradually filled by the sand dunes, much as Pinaki is filling now.

At Pinaki (Whitsunday Island), there is no doubt that the lagoon is rapidly filling from the sand blown in by the dunes. They are from 12 to 15 feet high, and are forcing their way in

towards the lagoon, killing the pandanus and whatever vegetation there is growing on the land rim of the lagoon. The dunes have probably filled also a second entrance to the lagoon indicated now only by a somewhat lower level of the land rim. Mr. Moore and Mr. Townsend, who went ashore at Pinaki, report that the lagoon is not more than 3 fathoms deep; they could wade over the greater part of it. Mr. Alexander counted no less than 116 islets in this small lagoon—less than a mile in diameter—islets formed of masses of dead Tridacna shells thrown up on ledge rock, on the slopes of which grew madrepores. The bottom of the lagoon is covered by Tridacna and masses of a species of Arca live near the edge; the intervening spaces being filled with nullipores. The entrance to the lagoon is perhaps 150 feet wide, and there is a cut through the beach rock covering the old ledge giving access to the sea into the lagoon at certain stages of the tide. The water in the lagoon is quite warm.

At Pinaki, as at other atolls and islets to the eastward, there are fewer cocoanuts than on the westward atolls, and the vegetation consists in great part of pandanus and puteau trees and the usual coral reef vegetation of the Paumotus and Fijis.

The only atoll we have seen, the lagoon of which is entirely shut off from the sea, is Niau. In this case the old ledge forming the rim of the land, which surrounds the nearly circular lagoon, is about a third of a mile in width and sufficiently high, 15 to 20 feet, to prevent any sea from having access to it except in case of a cyclone, as that of 1878, when the sea washed into the lagoon. The lagoon is shallow, of an average depth of about 3 fathoms, the deeper parts perhaps 5. The water is brackish, of a density of 1·0216 at 28° C. There are no corals living in it, but a species of mullet is found, as well as many marine shells, which, like those in the lagoons of San Salvador, in the Bahamas, are of diminutive size compared to their representatives living outside. The floor of the lagoon is covered with algæ. The lagoon has probably a slight connection with the sea, the water percolating through the limestone ring separating it from the outer reef flat. It is very difficult in this case to decide whether this lagoon has been gradually filled up after elevation, or whether it is merely a sink on a more or less uneven limestone surface.

Dana, and other writers on coral reefs, mention a great number of lagoons as being absolutely shut off from the sea. I take it these statements are due to their descriptions being taken from charts, many of which, as in the case of the Paumotus, are very defective. For nothing is easier than to pass at a short distance by the wide and narrow cuts which give in so many cases the freest access to the sea to the interior of the

lagoons, and described as closed because they have no boat passages. I could mention as instances of such lagoons, those of the atolls of Takume, Hikuero, Anaa, etc., which may be said to be closed, yet into which a huge volume of water is poured at every tide over low parts of the encircling reef flats.

The character of the coral reefs of the Paumotus is very different from that of other coral reef regions I have seen. Nowhere have I seen such a small number of genera, so many small species, and such stunted development of the corals. None of the great heads of the genera so characteristic of the West Indian regions, or of the Great Barrier Reef of Australia, are to be seen, with the exception of a couple of species of alcyonaria they are absent, so far as our experience shows, and there are but few sponges and gorgonians to be found among the corals. The bathymetrical limit of the reef-building coral seems to be about 20 to 22 fathoms, but nowhere have I seen such extraordinary development of incrusting nullipores as on the sea edge of the shore platforms of some of the Paumotus atolls, where they build up to a height often of 4 feet to form the outer edge of the secondary barrier reef so frequently seen along the reef faces of the Paumotus.

Judging from the temperatures taken at various points, 40° F. seems to be found quite generally at about 500 fathoms depth.

We made a number of surface hauls, as well as intermediate hauls with the tow nets, but obtained very little animal life. The poverty of the surface pelagic life and down to 300 fathoms is remarkable. I do not think I have ever sailed over so extensive an area as that of the Paumotus and observed so little surface life; on calm days, under the most favorable conditions, nothing could be seen with the naked eye, and at night there was little or no phosphorescence. Inside of the lagoons our hauls were equally barren.

The same paucity of animal life seemed to extend to the deepwater fauna. All the hauls we made off the islands, in from 600 to 1,000 fathoms, usually the most productive area of a sea slope, brought nothing, or so little that we came to grudge the time spent in trawling on the bottom, as well as towing on the surface or near it, a great contrast to the conditions in the Atlantic in similar latitudes, and very different from our anticipations.

For these reasons no attempt has thus far been made to make a trial of the deep sea pump while in such unproductive areas, and unfortunately while we were in the region of the equatorial currents the weather conditions were not suited for a trial of the apparatus.

ART. X. — *The Action of Ammonium Chloride upon Analcite and Leucite;* by F. W. CLARKE and GEORGE STEIGER.

IN a recent paper* upon the constitution of certain silicates, we showed that analcite, when heated with ammonium chloride, gave up a part of its soda, and absorbed ammonia to an appreciable extent. This result was so remarkable that it seemed to demand further investigation, upon material of different origin, and with variation in the details. The new experiments, which have led to highly interesting consequences, are now to be described.

The analcite previously studied was from Nova Scotia. To the kindness of President Regis Chauvenet of the State School of Mines we are indebted for a liberal supply of well-crystallized material from North Table Mountain, near Golden, Colorado, of which a uniform sample of about eighty grams was prepared. Upon this sample the present series of experiments has been conducted. Analysis of the analcite gave the following results:

Analysis.		Water by fractions.	
SiO_2	55·72	At 100°	·13
Al_2O_3	23·06	" 180°	·75
CaO	·17	" 260°	2·44
Na_2O	12·46	" 300°	1·28
H_2O at 100°	·13	" 350°	1·76
H_2O above 100°	8·26	" redness	2·03
	99·80	Total	8 39

Above a low red heat no further loss of weight was observed. Upon boiling the powdered mineral for fifteen minutes with a twenty-five per cent solution of sodium carbonate, 0·45 per cent of silica was dissolved. After ignition, 0·57 per cent was soluble, which is practically the same amount. No silica was split off by heating.

The experiments with ammonium chloride fall into two series. The first of these was conducted precisely as in our former investigation, by grinding the powdered mineral into an intimate mixture with four times its weight of chloride, and heating in an open crucible. In three cases the material, after volatilization of the ammonium chloride, was reground with a fresh amount of the salt, and then heated again. The temperature and duration of the experiments was purposely somewhat varied. After heating, the material was leached out with

* This Journal, October, 1899.

water, the sodium chloride which had been formed was estimated, and in the residue the fixed ammonia was determined.

In this series there were four experiments, with results as follows:

	Hours heated.	Temperature.	Soda removed.	Ammonia in residue.
A	28	300°	4·75	2·04
B	$8\frac{1}{2}$	350°	6·36	2·88
C	26	350°	3·76	1·72
D	5	340° to 380°	6·70	2·85

In our work upon the analcite from Nova Scotia the ammonia retained by the leached residue ranged from 2·03 to 2·36 per cent, while the extracted soda varied from 5·07 to 6·10. In two of the new experiments these figures are perceptibly exceeded, and they represent the shortest duration of heating. Prolonged heating seems to be undesirable, and to undo a part of the reaction which has taken place; otherwise the results obtained are of the same order as their predecessors. *About* one-half of the soda in the analcite is converted into chloride, while variable ammonia is retained.

In the second series of experiments a sealed tube was substituted for the open crucible. The powdered analcite was intimately ground with four times its weight of ammonium chloride, as before, and then heated to 350° in a tube furnace for from four to eleven hours. Under these conditions practically the whole of the soda in the mineral was converted into sodium chloride, while all of the liberated ammonia was absorbed by the residual silicate. Upon leaching the contents of the tube with water, to remove sodium and ammonium chlorides, a residue was obtained which exhibited constant composition whether dried at 100° or at the ordinary temperature of the air. Three samples of the residue were prepared and analyzed; other samples were partially examined and used for subsidiary experiments. The three analyses, lettered for future reference, were as follows, the analcite itself being included in the table for comparison.

	Analcite.	Residue A.	Residue B.	Residue C.
SiO_2	55·72	61·93	61·68	61·79
Al_2O_3	23·06	25·21	25·33	25·24
CaO	·17	----	----	----
Na_2O	12·46	·40	·22	·28
NH_3	----	7·23	6·95	7·71
H_2O	8·39	4·50	4·91	5·01
	99·80	99·27	99·09	100·03

Residue C was prepared with the greatest care, and was air dried. Exposed over sulphuric acid in a vacuum desiccator for

fourteen days, it lost in weight only 0·08 per cent. Tested for chlorine, only a slight trace could be recognized, but upon boiling for fifteen minutes with sodium carbonate solution it yielded 1·97 of soluble silica. After ignition only 1·70 of silica was soluble, or somewhat less than before. Upon heating to constant weight at 300°, only 0·46 per cent was lost; but at 350° it slowly decomposed, giving off ammonia. At 300° the compound is stable.

The 0·28 per cent of soda remaining in residue C may be regarded as representing unaltered analcite; doubtless coarser particles which escaped complete transformation. It corresponds to 1·98 per cent of analcite; which, together with the 1·97 of soluble silica, and the 0·46 of water lost below 300°, may be deducted from the substance in order to obtain the composition of the definite compound. The latter amounts to 94·72 per cent of the total residue, and agrees very nearly in composition with the formula

$$2NH_3.H_2O.Al_2O_3.4SiO_2.$$

Recalculating the 94·72 of residue to 100 per cent, we get the following comparison between analysis and theory.

	Found.	Calculated.
SiO_2	61·07	60·92
Al_2O_3	26·15	25·88
NH_3	8·14	8·63
H_2O	4·64	4·57
	100·00	100·00

Written in rational form the compound becomes equivalent to an anhydrous ammonium analcite,

$$NH_4AlSi_2O_6;$$

that is, analcite in which sodium has been replaced by ammonium. From this point of view the reaction between analcite and ammonium chloride becomes a simple case of double decomposition, and is perfectly intelligible. To establish this conclusion, however, corroborative experiments were necessary.

In the first place, the observed equivalency between the sodium lost and the ammonia gained might be due to a mere coincidence, and so far be illusory. One atom of sodium, taking chlorine from ammonium chloride, liberates one molecule of ammonia, the amount which the analcite residue has retained. Suppose more ammonia were present,—could it be absorbed?

To answer this question another tube was prepared, with the usual mixture of analcite and ammonium chloride. This was covered by a loose plug of glass wool, in front of which we placed enough pure lime to liberate about double the normal

amount of ammonia. The tube was then sealed, and heated to 350° as in the previous experiments. Upon opening the tube, a strong outrush of ammonia was noticed; but in the leached and thoroughly washed residue only 7·52 per cent of ammonia was found. This quantity agrees with that from the previous samples, and shows that the limit of the reaction has been practically reached. One molecule of ammonia is retained, and no more.

Still another experiment was tried upon a portion of the residue marked C. If the compound is really an ammonium salt, it should be decomposable by caustic soda in such a way as to reverse the reaction by which it had been obtained. The substance, however, is very insoluble, so that the reaction takes place slowly. To phenol phthalein it is absolutely neutral, and with Nessler's reagent it reacts only after long standing.

To settle the question a weighed portion of the compound was boiled in a distilling flask with a ten per cent solution of sodium hydroxide, to which water was added from time to time. The distillate was collected in a tube containing aqueous hydrochloric acid; and the ammonia which passed over was weighed, ultimately as chloroplatinate. By four hours boiling 6·90 per cent of ammonia was driven off and determined; and the residue remaining in the flask, after washing until no alkaline reaction could be detected in the wash-water, was examined for soda, of which 10·41 per cent was found. The anticipated reaction had taken place, although not completely; it was enough, however, to confirm our opinion, and to establish the nature of the new compound beyond reasonable doubt. Other confirmation was obtained later, from the study of leucite.

The foregoing paragraphs now enable us to understand a phenomenon which we observed in our work with the open crucible. In that case a partial reaction takes place between the analcite and the ammonium chloride, producing, as in the sealed tube, a mixture of an ammonium alumino-silicate with sodium chloride; the two substances being separable by leaching. But if, instead of leaching, the mixture be heated to full redness, ammonium chloride is reformed and given off, leaving a residue which contains little or no sodium chloride, and is wholly insoluble, or almost so, in water. That is, the reaction which occurs at 350° is reversed at the higher temperature, and anhydrous analcite, or an isomer of it, is regenerated. Ammonium and sodium again change places, and the original state of molecular equilibrium is restored.

What, now, is the nature of the product obtained in the open crucible, after sodium chloride has been removed? Is it a definite, intermediate compound, or an indeterminate mixture? In our former paper we adopted the first of these

alternatives, and assigned to the substance the formula $H_2Na_2Al_4Si_8O_{24}.NH_3$. In this expression we were influenced by the researches of Friedel, who had shown that ammonia could in part replace the "zeolitic" water of analcite; but it now appears that the phenomenon observed by him is quite distinct from that discovered by us, and, indeed, of an entirely different order. We may, therefore, in accordance with our new data, rearrange the formula; transforming it to that of an ammonium salt, $HNa_2NH_4Al_4Si_8O_{24}$, the agreement with the analytical figures being approximate only. The results obtained are not sharp enough for certainty.

This product we are now inclined to regard as a mixture, although it is not strictly intermediate between analcite and its final ammonium derivative. Only half of the eliminated sodium has been replaced by ammonium, while hydrogen, or water, makes up the deficiency. It seems probable that the reaction in the sealed tube and that in the open crucible are at first essentially the same; but that in the latter case secondary reactions follow which cause the variations in the final results. In the sealed tube, the element of pressure comes into play, and the reaction is complete. In the open crucible, pressure is lacking; some ammonia escapes fixation and reacts upon a part of the sodium chloride which was at first formed; hence the composition of the leached residue is essentially modified. This residue may be a definite compound; but the case in its favor is unproved, and the presumption is rather against it.

Between analcite and leucite the closest analogies have long been recognized. The two minerals have similar composition, they resemble each other in crystalline form, and they yield, upon alteration, products of the same order. Recently also, analcite, like leucite, has been identified as a not uncommon constituent of volcanic rocks; analcite-basalt being a good example. In view of these resemblances, it was plainly desirable to compare the minerals by means of the ammonium chloride reaction; a task which has been performed with satisfactory results.

In a preliminary experiment a sample of leucite, taken without regard to purity, was heated with ammonium chloride to 350° in a sealed tube. Potassium chloride was formed corresponding to 18·06 per cent of potash, and in the leached residue 6·90 per cent of ammonia was found. The foreseen reaction had occurred, and more careful work was accordingly undertaken.

Our material consisted of a large, irregular crystal of leucite from Vesuvius, which yielded about twenty grams of the pure mineral. This was ground to a uniform sample, and a portion of it was analyzed; the analysis will be given presently. The

sealed tube experiments were conducted precisely as in the case of analcite, and they confirmed both the preliminary test and our anticipations. Chlorides were formed equivalent to 18·53 per cent of potash, 1·08 of soda, and 0·08 of alumina; the reaction therefore, was very nearly complete. The leached residue was then analyzed, and the data, compared with the analysis of the original mineral, were as follows:

	Leucite.	Residue.
SiO_2	55·40	60·63
Al_2O_3	23·69	26·44
CaO	·16	trace
K_2O	19·54	·50
Na_2O	1·25	·25
NH_3	----	7·35
H_2O	·24	5·17
	100·28	100·34

Leucite, then, gives the same reaction as analcite, and yields the same ammonium compound. A closer agreement in the composition of the latter could not reasonably be demanded. Ammonium leucite is formed in both cases, by ordinary double decomposition, in a state of approximate purity; the first silicate of ammonium, we think, which has ever been prepared. At the suggestion of Dr. F. K. Cameron an attempt was made to transform ammonium leucite into the corresponding lime salt, $CaAl_2Si_4O_{12}$, by fusion with calcium chloride. The ammonium leucite was mixed with a saturated solution of calcium chloride, which was evaporated to dryness, then heated gradually to dehydration, and finally fused. Ammonium chloride was given off and identified. Upon treating the fused mass with water, filtering, and thoroughly washing the residue, a white powder was obtained, which after drying at 100°, was analyzed. It was also examined microscopically by Mr. J. S. Diller, who found it to consist of apparently isotropic grains, showing traces of incipient crystallization. The following analysis is contrasted with the theoretical composition of calcium leucite, from which it varies considerably.

	Found.	Calculated.
SiO_2	54·35	60·30
Al_2O_3	26·23	25·63
CaO	17·38	14·07
K_2O	·16	----
Na_2O	·25	----
Cl	·28	----
Loss on ignition	1·24	----
	99·89	100·00

Evidently, the desired salt was not definitely obtained, and the product appears to be a mixture. The reaction, however, tends in the right direction, and deserves further study under other conditions. Probably the water which was present in the mixture of silicate and chloride took part in the changes produced; although of this we cannot be certain. It is interesting to note that the product obtained approximates in composition to the meteoritic mineral maskelynite, which is regarded as perhaps a calcium leucite by Groth.

The question now arises whether the observed reaction with ammonium chloride is limited to a few species or is fairly general. To test this point we have made preliminary experiments upon a number of other minerals, heating in a sealed tube to 350°, with the following results: The percentage of bases removed is calculated in each case upon the original minerals; that of the ammonia is the amount found in the leached and washed residue.

Natrolite.—17·56 per cent of soda removed, 8·29 of ammonia taken up.

Laumontite.—4·51 of lime and 0·35 of soda removed, 3·95 of ammonia absorbed.

Stilbite.—6·54 of lime and 1·31 of soda extracted, 5·36 of ammonia in the residue.

Chabazite.—4·37 of lime and 1·13 of soda removed, 4·55 of ammonia retained.

Thomsonite.—7·94 of lime and 3·40 of soda extracted, 4·01 of ammonia taken up.

Heulandite.—4·59 of lime and 1·59 of soda extracted, 3·64 of ammonia retained.

Apophyllite.—21·59 of lime and 5·18 of potash removed, 0·79 of ammonia in residue.

Pectolite.—20·72 of lime and 6·46 of soda extracted, 1·44 of ammonia retained.

Elaeolite.—2·25 of soda taken out, 0·74 of ammonia retained.

It will at once be seen that the reaction takes place in most cases, but with varying completeness. In some instances the decomposition is very slight, in others it is near the possible limit. In each case the ammonia of the residue was obtained by decomposing the material with hydrochloric acid, supersaturating with caustic soda, distilling into tubes containing hydrochloric acid, and final weighing as ammonium chloroplatinate. Each of the minerals mentioned is to be studied more thoroughly hereafter, and prehnite, sodalite, and possibly other silicates will be added to the list.

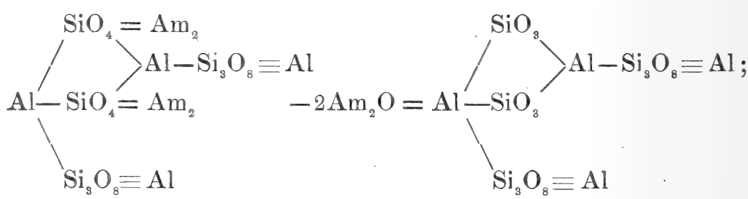
It is evident that all of the zeolites are well suited to this new method of study, and it is more than probable that the differences in the action of ammonium chloride upon them cor-

respond to differences in their chemical structure. But the reaction goes further than this, for it enables us to substitute in many minerals a volatile base for fixed bases, yielding silicates which split up on ignition in such a way as to shed light upon their molecular constitution.

For example, if ammonium leucite is a true metasilicate, a salt of the acid H_2SiO_3, it should break up, when ignited, in accordance with the following equation:

$$2NH_4Al(SiO_3)_2 = Al_2(SiO_3)_3 + 2NH_3 + H_2O + SiO_2;$$

that is, one-fourth of the silica ought to be set free, measurable by extraction with sodium carbonate solution. No such splitting off occurs, however; an ammonium leucite which already contained 1·97 per cent of soluble silica gave only 1·70 per cent after ignition; hence no additional silica had been liberated. We may conclude, therefore, that analcite and leucite are not true metasilicates but pseudo compounds; either salts of a polymeric metasilicic acid or mixtures of ortho-and tri-silicates as suggested in our former paper. The ammonium salt corresponding to such a mixture, when ignited, might be expected to give the following reaction:



a reaction which is in harmony with our experimental results. In it no free silica appears; and many, if not all, conditions of the problem are satisfied. Other formulæ, however, are possible; so that these offer merely one explanation of the phenomena, which one may or may not be the best.

ART. XI.—*Devonian Strata in Colorado;* by ARTHUR C. SPENCER.

Early recognition of Devonian.—The presence of Devonian strata in the San Juan region of Southwestern Colorado was announced in the report of F. M. Endlich, of the Hayden Survey, for the year 1874. The age determination, based upon a small collection of fossils, was made by F. B. Meek, the paleontologist of the Hayden Survey, and upon the evidence of this determination the geological map of Southwestern Colorado in the Hayden atlas, which appeared in 1877, had Devonian areas represented upon it. This work, however, has been either lost sight of, or discredited by recent writers upon the geology of the Rocky Mountains. In his paper upon "Orographic Movements in the Rocky Mountains," S. F. Emmons* indicates that of the areas represented upon the Hayden map as Devonian and Carboniferous, the lower part is known to be Silurian, though the facts on which this opinion was founded are not given. Again in a paper upon "Orographic and Structural Features of Rocky Mountain Geology," R. C. Hills† states, without qualification, that there are no recognizable Devonian sediments between the Silurian and Carboniferous in the San Juan region. He, however, expresses the belief that Devonian strata may yet be found in Southwestern Colorado.

Further information concerning the strata from which Endlich collected the fossils, pronounced by Meek to be Devonian, has recently been obtained by the Geological Survey party in charge of Dr. Whitman Cross, while engaged in areal mapping. The writer was a member of the party, both in 1897, when the fossiliferous limestones were found, and in 1898, when extensive collections were made. The actual localities which Endlich mentions have not been revisited as yet, but all the forms which he found, together with many others, have been obtained from beds in the Animas valley, which are evidently connected by continuous outcrop with the Devonian areas mapped by Endlich.

The fossils which Endlich collected have been preserved in the National Museum, where there are, also, other collections from beds in Central Colorado which now prove to be related to those of the San Juan region. These fossils have been made the subject of careful study by Dr. Geo. H. Girty of the U. S. Geological Survey, in connection with the determination of the more recent collections. The result of Dr. Girty's

* Bull. Geol. Soc. Am., i, p. 280. † Proc. Sci. Soc. Colo., iii, p. 366.

investigation has been to confirm Meek's opinion of the Devonian age of the fossils which were found by Endlich, and to establish the basis for a correlation of the Devonian of the San Juan region with strata in other parts of the State which have hitherto been included in the Lower Carboniferous.

Devonian in Southwestern Colorado.—The Devonian rocks are at present the oldest formations which are well authenticated in the San Juan region of Southwestern Colorado. Silurian was represented upon the Hayden map in Endlich's area, and though the areal distribution of the lower formations, as there shown, is very incorrect and gives no basis for a conclusion, it is thought from the text* that his Silurian is the basal quartzite of our section. The quartzite is wanting or of very limited development on the east side of the Animas river, where the Devonian was first discovered by Endlich, while it is very prominent in the vicinity of Cascade creek where his Silurian is indicated. The incompleteness of the Hayden map in regard to the basal portion of the sedimentary section is to be wondered at, since at no place where it has thus far been studied by us is the Devonian limestone absent between the crystalline basement and the rocks of well-recognized Carboniferous age.

The series below the Carboniferous consists typically of three members, a sandstone or quartzite at the base, a shale series, and a massive limestone. Of these, the lowest is frequently wanting through non-deposition, and the middle member is also sometimes very thin or entirely absent. The formation name, Ouray limestone, is proposed for the only member of the section which is definitely shown by its fossils to be of Devonian age, from the prominent occurrence in the vicinity of Ouray at the junction of Cañon creek with the Uncompaghre river. No names will be proposed for the lower formations at present, since, for purposes of mapping, it may prove necessary to include them under a single name.

Above the Devonian there is apparent conformity of deposition, but the occurrence of Upper Carboniferous fossils within a few feet of the Devonian limestone, and the absence of any fauna comparable with the Lower Carboniferous fauna from the Gunnison region and from Tourtelotte park, suggests a gap in deposition which represents the whole of the Lower Carboniferous. There is, however, a possibility that there may be a few feet of unfossiliferous limestone above the true Devonian, and not differentiated from it, which is really of Lower Carboniferous age. Such a lack of lithological difference would

* Hayden Geol. and Geog. Surv. of Terr., Report of F. M. Endlich for 1874, p. 210.

be quite analogous to the relations observed between the two formations in other places.

The most important areas of Devonian lie in the region south and west of the pre-Paleozoic core of the Needle Mountains. (Quartzite Mountains of the Hayden map.) The Ouray limestone has been noted as far east as Los Pinos river, and may be traced across the Florida river, and still westward to the Animas, where it was first observed by the writer. Detailed studies have not been made throughout this region, but the two lower members of the section are known to be locally absent. All of them are present along the west side of the Animas river for about twenty-five miles, from their southernmost outcrop about thirteen miles north of Durango, at Pinkerton Springs, to where they are covered by volcanic rocks of Tertiary age, just south of Silverton. In the vicinity of Ouray this formation rests upon the Algonkian rocks, the lower beds being absent. Southeast of Silverton, in Deer Park, and along the Bare creek trail, the quartzite is locally missing, while the shaly series is always present underneath the limestone. Still farther east and more to the north, upon the headwaters of the Lake Fork of the Gunnison river, none of the Devonian formations are found in place, but several huge blocks of quartzite and limestone like those of the Devonian were observed in the lower part of the great complex of effusive rocks which covers that region. Apparently these were wrenched off during some eruption and floated up by the fluid or viscous rhyolite lava, to be subsequently covered by streams of andesite and similar rhyolite. The Ouray limestone has also been identified in the marbleized limestones which appear near the center of the remarkable structural dome at Rico, some fifteen miles west of the Animas valley, opposite the Needle mountains. The known occurrences of the Devonian thus indicate its distribution over an area of approximately six hundred square miles in the San Juan region, with every reason for supposing an actual extent very much in excess of this.

The relations of the formations indicate an overlap, and, therefore, an advancing sea during the period of their deposition; however, the vertical element of the overlap was, at the most, not more than 200 feet. Thus, the relations of the sediments to their basement is indicative of a surface of very low relief in the pre-Devonian topography.

The quartzite which forms the basal member of the series here considered varies in thickness from zero to perhaps 100 feet. It is typically a massive white or reddish quartzite in which a well marked jointing is usually developed. It is composed almost entirely of quartz and its grain is rather fine and

uniform. Local variations are observed where the sandstone is flaggy, and conglomerates of medium coarseness are not rare in the lower part. Near the southernmost exposures in the vicinity of Rockwood, the contact with the basement rock, which at that place is granite, is marked by a basal conglomerate some six feet in thickness. The bowlders in this conglomerate, which have a diameter of six inches or more, are confined to the slight depressions in the floor. Above the conglomerate, and running over the tops of the knolls, there comes a fine-grained sandstone or quartzite. At the top of the quartzite there is an alteration of red or gray earthy limestone with reddish shales for a thickness of a few feet. The lowest of the earthy limestones is luted onto the topmost layer of the quartzite. The materials of this basal formation are remarkable in that they contain no fragments of feldspar though they rest directly upon a coarse granite, and that the bowlders were not derived from the rocks which immediately underlie the conglomerate. Such a formation is not the result of a rapidly advancing coast-line, but is rather the effect of activities which must have been long continued.

The occurrence of fish scales in the sandstone of the basal formation was reported by Endlich, and a single slab exhibiting fish remains was found by us in a talus pile at the base of a quartzite cliff near Rockwood, on the Silverton branch of the Denver and Rio Grande Railroad. The only other fossils from the quartzite are very imperfect impressions, which Mr. Walcott is inclined to refer to *Cruziana* or *Rusophycus*, supposed plants which are respectively of Silurian and Cambrian types.

The middle or shaly member varies in thickness from 25 to perhaps 100 feet in the Animas region. As already stated, it is missing in the Uncompahgre region. The shale series is very imperfectly exposed upon the west side of the Animas river, but upon the east side it may be studied at several places. It is especially well exposed in the high basins at the head of Deer Park, southeast of Silverton. It consists of calcareous marls and flaggy shales containing an occasional band of white sandstone. In color it has a somewhat variegated appearance, due to alternating bands of red, green and gray color. Wherever it is exposed, or wherever talus derived from it is found, it may be readily recognized from its general appearance. One of the most characteristic features is the appearance of slabs of sandy shale, which contain the curious markings that are known to represent crystals of halite, showing hopper-shaped crystals preserved as pseudomorphs in the substance of the rock.

The Ouray limestone is a massive limestone varying in thickness from 100 to 300 feet. In places the limestone is in one massive layer, while elsewhere it is in two or three heavy bands separated by greenish crumbling marls. The limestone is usually white, but is sometimes stained red or pink. Certain strata are somewhat coarsely crystalline, but as a rule the limestone is fine-grained. The chemical composition is variable, as is shown by the careful selection of certain portions for use in the smelter at Durango. The discarded portion is said to be too siliceous for metallurgical use.

The total thickness of the Devonian in the Animas region varies from 200 to nearly 500 feet, the former figure representing the usual development. At Ouray the thickness is not far from 200 feet.

The fossils which have enabled a determination of the age of this series are found in the limestone a short distance below the top. Neither the extreme upper or lower layers have thus far yielded organic remains. In the zone in which the shells occur there are several thin layers which are more coarsely crystalline than the mass of the limestone, and these are very frequently fossiliferous. The fossils are never prominent to casual observation, but when their horizon is once located and patiently searched, it usually proves to be quite productive. In some places, however, where many fossils are present, collecting proves unsatisfactory because of minute jointing which makes it impossible to secure perfect specimens. A list of the forms which have been recognized is here given:

Streptelasma sp.
Schizophoria striatula.
Orthothetes chemungensis var.
Productella semiglobosa.
Productella subalata?
Spirifer disjunctus var. *Animasensis.*
Spirifer coniculus.
Athyris coloradœnsis.
Athyris vittata var.
Camarotœchia (*Rhynconella*) Endlichi.
Camarotœchia contracta?
Mytilarca? sp.
Paracyclas sp.
Modiomorpha sp.
Allorisma sp.
Euomphalus clymenioides.
Euomphalus Decewyi.
Pleurotomaria sp.
Naticopsis? humilis.
Naticopsis gigantea.
Bellerophon sp.
Orthoceras sp. a.
Orthoceras sp. b.
Orthoceras sp. c.

Devonian Strata in Central Colorado.—In the course of the geological studies which have been made from time to time in Central Colorado, under the direction of Mr. S. F. Emmons of the U. S. Geological Survey, the determination of the presence or absence of Devonian rocks was a problem most difficult of satisfactory solution. Only the recent work at

Aspen has given any evidence of a positive nature, but a re-examination by Dr. Girty of the fossils collected at various localities in the central portion of the State has resulted in establishing the occurrence of Devonian strata in this region. It seems desirable to bring together in this place all the available information concerning the strata of Central Colorado which are now known to be of Devonian age. Some of the data have not been published hitherto.

At Leadville Emmons* was not able to find strata which could be referred with certainty to the Devonian. A meagre Silurian fauna was found in the lower part of the sedimentary series, while higher in the section, Carboniferous fossils were also found, but between these there was a considerable thickness of strata from which no organic remains were obtained. In the absence of adequate fossils, and in view of the opinion expressed by R. P. Whitfield,† that the characters of *Rhynconella Endlichi* were Carboniferous rather than Devonian, it was concluded that Devonian strata had not yet been found in Colorado, and it was thought advisable to apportion the lower part of the Paleozoic section between the Silurian and the Carboniferous. Between the white limestone of the Silurian and the blue limestone, which was classified as Lower Carboniferous because of the fossils which were found in its upper part, there is a quartzite which is typically about forty feet in thickness. This siliceous band was called the "Parting Quartzite" and it was given position as the uppermost member of the Silurian. Between it and the fossiliferous horizons of the blue limestone there are nearly 200 feet of limestone which are entirely unfossiliferous. It is this portion of the limestone immediately above the "Parting Quartzite" that probably corresponds with the Devonian of the Gunnison and Salida sections, described in what follows.

With the knowledge gained in the Leadville work, Mr. Emmons was able to establish the general correspondence of the Paleozoic rocks at several places adjacent, and his general results have been found correct by those who have made more detailed examinations under his direction.

During the field seasons of 1885–86, Mr. George H. Eldridge was engaged in the study of the stratified rocks of the Gunnison region. At this time, he also made careful sections and collections in the vicinity of Salida. At both places, Mr. Eldridge was able to recognize the "Parting Quartzite," and in the limestone strata which immediately overlie it, fossils

* Geology and Mining Industry of Leadville. Monograph U. S. Geol. Surv., xii, p. 56.

† Idem.

were found which had a Devonian aspect, but, in the absence of any stratigraphic criterion, the data were not considered to be sufficient to warrant the mapping or the description of the Devonian in the Anthracite-Crested Butte Folio, published in 1894. Part of the fossils which were collected in this region are in the National Museum and have been examined by Dr. Girty, who finds among them forms identical with those from the Devonian limestone from the San Juan region. The Devonian fauna is succeeded by a characteristic assemblage of Lower Carboniferous forms.

In the summer of 1889, at the instance of Mr. Emmons, a careful search for fossils was made by T. W. Stanton, in the lower Paleozoic strata near Glenwood Springs. *Rhynconella Endlichi* was one of the few forms collected, the rest being either Lower Carboniferous or pre-Devonian. At the time, this was taken as negative evidenee in favor of the absence of Devonian, but since *Rhynconella Endlichi* is now known to be of that age, it seems probable that the Devonian limestones are present at this place. The "Parting Quartzite" is also probably present, though its true relations are obscured by the faulting which has taken place.*

At Aspen, Spurr† has described the same stratigraphic elements as those recognized at Leadville: the white limestone, the "Parting Quartzite," and the blue limestone are all present. Fish remains of a Devonian type, which were found in the "Parting Quartzite," furnish the basis for correlating this series with the Devonian of the Kanab valley in Southern Utah and Northern Arizona, as described by Walcott.‡ The stratigraphic position and lithology of the siliceous series in both regions are similar and have been considered by Spurr a sufficient basis of correlation.

The fossils occurring at Salida have been determined as follows:

Monotrypella sps. a, b, and c.
Schizophoria striatula.
Orthothetes Chemungensis.
Orthothetes Chemungensis var.
Productella subalata?
Productella subalata var.
Productella semiglobosa.
Spirifer disjunctus var. *Animasensis.*
Athyris Coloradœnsis.
Camarotœchia (*Rhynconella*) *Endlichi.*
Camarotœchia contracta?
Euomphalus clymenioides.
Orthoceras sp. a.

* Opinion of Mr. Emmons in conversation.
† Monographs of U. S. Geol. Survey, xxxi, pp. 9–30.
‡ This Journal, xx, p. 224.

In the Gunnison region the following forms were found:

Streptelasma sp.
Chætetes sp.
Monotrypella sp. b.
Schizophoria striatula.
Orthis sp.
Orthothetes Chemungensis var.
Chonetes sp.
Productella semiglobosa.
Spirifer disjunctus var. *Animasensis.*
Athyris Coloradœnsis.
Camarotœchia (*Rhynconella*) *Endlichi.*
Camarotœchia contracta ?
Naticopsis ? humilis.

Other localities which are represented in the collections of the U. S. National Museum have yielded some of the forms listed above. The labels are not definite, but show the occurrence of the fauna over a wider area than that in which the section has been studied in detail. They are as follows: Massive limestone of White river, Colorado; Cañon of Cement creek, Colorado; Northwestern Colorado; Southwestern Colorado.

After a comparison of the fossils from the various localities, Dr. Girty says: "The strata from which these forms have been collected are without doubt of Devonian age. As they have essentially the same fauna, I refer them to the same horizon, which I take to be well up in the Devonian. In my opinion, it probably belongs below the Chemung, at about the base of the Upper or near the top of the Lower Devonian. While this fauna is clearly related to other fossil assemblages of our western Devonian, it cannot be said to be strictly identical with any one of them, for its common forms, *Spirifer disjunctus* var. *Animasensis*, *Athyris Coloradœnsis*, and *Camarotœchia Endlichi*, which, so far as I am aware, have not been found elsewhere, give it considerable individuality. Of the faunas with which I am familiar, it most closely resembles that described by Whiteaves from Hay river, Canada, and from other parts of the Mackenzie region."

Correlation.—The combined evidence furnished by paleontology and stratigraphy, as set forth in the preceding paragraphs, is thought to be sufficient to establish the practical equivalency of formations of Devonian age occurring in widely separated localities of Colorado, Utah and Arizona. The "Parting Quartzite" has been a datum of reference in all the geological investigations in the Central region of Colorado. With the discovery of its age as Devonian its equivalence with strata of that age in the Grand Cañon district was established, and now it is found to be represented in the San Juan region of Colorado. The evidence upon which this correlation rests, is the occurrence of fish remains of similar types in the three regions, and the corresponding position which the siliceous

series occupies below the Devonian limestone, in the San Juan region, and in certain localities in Central Colorado.

Fossils from the limestone immediately above the "Parting Quartzite" in the Gunnison region and at Salida are found to represent a fauna which is identical with that obtained from the Devonian limestone occurring above the siliceous series in the San Juan region. The correlation is thus firmly established, both as regards the limestone and the siliceous beds beneath it. It must be borne in mind, however, that in the San Juan region the lowest strata may be older than Devonian. There is a suggestion of this in the poorly preserved plants from the lower part of the quartzite, but the unity of the quartzite member as a whole is distinctly against this view.*

Following up the correlation brought out by Spurr between the "Parting Quartzite" of Central Colorado and the Devonian of the Grand Cañon region, it is of interest to note that the lower part of the Red Wall limestone of the Grand Cañon, below the part which contains the well recognized Lower Carboniferous forms, is unfossiliferous. It was suggested by Gilbert† that the base of the Red Wall Carboniferous limestone had possibly been placed so low that it might include the Devonian and even part of the Silurian. Devonian rocks have since been found below it,‡ and if the sequence is parallel in Colorado and the Grand Cañon district, it is very probable that the lower part of the Red Wall limestone is equivalent in age as well as in position to the Devonian limestone of Colorado.

If the correlations here suggested are correct, it appears that Devonian and associated strata were originally deposited over an extensive area in the Southern Rocky Mountain region, the boundaries of which are as yet entirely unknown.

U. S. Geological Survey, June, 1899.

* While there is, in the mind of the writer, no reason for doubting the equivalence of the siliceous formations which he correlates with the "Parting Quartzite," he does not accept as conclusive the evidence concerning their age. The fish remains have been pronounced of Devonian types, but in no case have they been specifically determinable, and it is to be remembered that the fishes from the Lower Silurian near Cañon City are of types not previously known to occur below the Devonian.

† U. S. Geol. Surv. W. of 100th Mer., iii, p. 178.

‡ C. D. Walcott, loc. cit.

ART. XII. — *Sphalerite Crystals of a peculiar habit and with one New Form, from Galena, Kansas;* by AUSTIN F. ROGERS.*

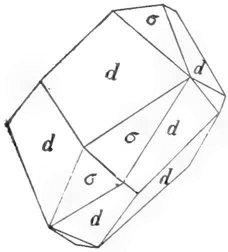
THE sphalerite crystals usually found in the lead and zinc district of southeastern Kansas and southwestern Missouri are those of the ordinary types which are tetrahedral in aspect. The commonest of these types is that which exhibits the following combination: $o(111)\,1$, $o_{,}(1\bar{1}1)\,\bar{1}$, $a(100)$ *i-i*. Of these forms the negative tetrahedron $o_{,}$ is usually the predominant one. During the past summer some crystals of a peculiar habit were obtained from this region, a description of which seems worthy of publication. They were collected by the writer at the Tennessee Prairie mines five miles south of Galena, Kansas. I take pleasure in expressing my thanks to Mr. Clark, superintendent of the mines, for his kindness in allowing free access to the ore bins and dump piles.

The crystals are reddish-brown in color and vary in size from one-half to three centimeters in longest diameter. They are found as isolated crystals in a dark clayey siliceous matrix and show no attachment. The associated minerals include dolomite, pyrite, and chalcopyrite, the two former of which occur in considerable quantities.

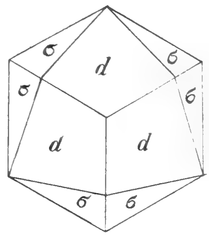
The peculiarity of these crystals is that they are abnormally developed, being shortened in the direction of one of the octahedral interaxes. The predominant faces are those of the rhombic dodecahedron. In consequence of this abnormal development the crystals appear as combinations of a rhombohedron with the prism of the second order. On account of the presence of certain faces soon to be described the crystals have a decided hemimorphic aspect in the direction of the above mentioned axis. Here, then, we have an isometric crystal possessing apparent lower symmetry, namely, that of the rhombohedral-hemimorphic group. Figures 1 and 2 represent crystals of this habit. Figure 1 is an ordinary clinographic projection, which is shortened in the direction of the octahedral interaxis connecting the faces $(1\bar{1}1)$ and $(\bar{1}1\bar{1})$. Figure 2 is an orthographic projection with $(1\bar{1}1)$ as the plane of projection. Truncating half of the dodecahedral edges are the faces of a hemi-tetragonal trisoctahedron, the form $\sigma(833)$, $\frac{8}{3}\text{-}\frac{8}{3}$ which seems to be new for sphalerite. As these faces and their combination edges with $d(110)$ are somewhat rounded and the faces are dull, no measurements with the reflecting

* Published by permission of the Director of the University Geological Survey of Kansas in advance of the final Report on Lead and Zinc.

1



2



goniometer were possible. The angle $\sigma \wedge \sigma$ over the edge $B\,(833 \wedge 8\bar{3}\bar{3})$ was measured with a contact goniometer giving the following results :

	Limits.	Average.	Calculated.
$\sigma \wedge \sigma\ (833 \wedge 8\bar{3}\bar{3})$ 12 measurements	55°–57°	55° 43′	55° 52½′

Angle measurements for the same form on crystals of normal habit from other localities in this district confirm these results. They are as follows :

	Limits.	Average.	Calculated.
$\sigma \wedge \sigma\ (833 \wedge 8\bar{3}\bar{3})$ 18 measurements	55°–56° 30′	55° 46′	55° 52½′

Occasionally the negative tetrahedron is present. The rough surface which it exhibits is characteristic of all the sphalerite crystals of the district.

Twins are more common than the simple crystals, which is also true of all the sphalerite crystals of the district. The twinning plane is the ordinary one for sphalerite, $o\,(111)\,1$. As no reëntrant angles are present, the twins may easily be mistaken for simple crystals, but they may be recognized as such by the fact that the prominent dodecahedral faces have no other dodecahedral faces parallel to them, and by the further fact that in the positive octants only two of the σ faces are united at one point while in the simple crystals three meet around this point.

Becke* has shown that the positive and negative character of the forms on sphalerite may be distinguished by means of etch-figures. He used hydrochloric acid, but fortunately some of the crystals here described exhibit natural etch-figures on the faces of the dodecahedron. One large twinned crystal measuring 25^{mm} by 30^{mm} shows them very well.

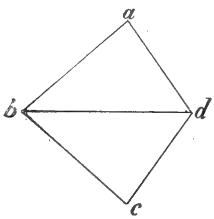
The etch-figures consist of "etch-hills"† which in plan appear as monosymmetric four sided figures, fig. 3, with the

* Becke, Tschermak's Min. u. Petr. Mitth., vol. v, p. 457, 1883.

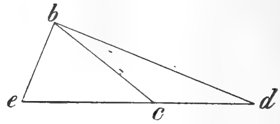
† For a recent discussion of the nomenclature of etch-figures see R. A. Daly, A Comparative Study of Etch-Figures; The Amphiboles and Pyroxenes. Proc. Am. Acad. of Arts and Sciences, vol. xxxiv, pp. 375 et seq.

axis of symmetry *bd* parallel to the shorter diagonal of the faces of the dodecahedron. Approximate measurements of the angles *abc* and *adc* gave 110° and 80° respectively. The solid angle at *b* is elevated above the general surface of the crystal, while the points *a*, *c*, and *d* are on this surface. In elevation, therefore, the etch-hills appear as in fig. 4. Here

3



4



the angle *ebd* is near 90°. The edges *ab* and *bc* and the solid angle at *b* are modified by minute faces which are not represented in the drawing. The "figure faces"* *abd* and *bcd* are highly polished and seem to reflect light at the same angle that the σ faces do, so that these figure-faces may perhaps be represented by the same symbol. The etch-figures resemble those described by Becke† except that the lines corresponding to *ab* and *bc* in fig. 3 are parallel to the edges of the dodecahedron while the lines in our figure are inclined about 20° thereto. In Becke's illustration the acute angle of the monosymmetric etch-figures points toward the negative octant. As this acute angle on our crystals points away from the σ faces, the latter are the faces of the positive hemi-tetragonal trisoctahedron σ (833), $\frac{8}{3}$-$\frac{8}{3}$ and the prominent dodecahedral faces are (101), (1$\bar{1}$0), and (0$\bar{1}$1).

In conclusion I wish to thank Prof. E. Haworth for suggestions in the preparation of this paper.

Mineralogical Laboratory, University of Kansas,
Lawrence, Kansas, December, 1899.

* Daly, loc. cit.

† Becke, loc. cit. Figure copied by Tschermak, Lehrbuch der Mineralogie, p. 145.

ART. XIII.—*On the Estimation of Thallium as the acid and neutral Sulphates;* by PHILIP E. BROWNING.

[Contributions from the Kent Chemical Laboratory of Yale University—XCIII.]

CROOKES* has shown that the salt obtained by heating thallous chloride with sulphuric acid until the excess of the latter is expelled and then raising the heat to redness has the constitution of a neutral sulphate.

He also found that continued heating did not result in any essential loss of weight, and suggested the possibility of applying this method of treatment to the estimation of thallium.

Castanjen† in a recent paper discusses thoroughly the compounds of thallium and confirms essentially the statements of Crookes in regard to the neutral sulphate, adding, however, the observation that on strong ignition in the air this salt tends to lose sulphuric acid. He also mentions in the same paper the acid sulphate and states that on heating it first melts and on continued heating gives off sulphuric acid, leaving the neutral sulphate.

The work to be described in this paper was undertaken to determine under what conditions the formation of these salts may be applied to the estimation of thallium. For the work a solution was made by dissolving a given amount of the nitrate in water and making up to a liter. The value of the solution was determined by precipitating measured and weighed amounts of this solution both as the iodide and chromate, as described in a previous paper.‡ Closely agreeing results by both methods were taken as the standard. Measured amounts of this solution were drawn from a burette into weighed platinum crucibles, and the weight taken as a check on the burette reading. To the solution in the crucible a few drops of sulphuric acid was added and the water removed by evaporation over a steam bath. The crucible was then removed to a radiator, consisting in this work of a conical iron cup, and heated at a temperature ranging from 220° C. to 240° C., until fuming ceased and the weight after half hour periods of heating remained constant. The crucibles were placed in a radiator upon a pipe stem triangle so that they were about 5^{cm} from the bottom, which was heated at low redness. A thermometer hung so that the bulb occupied the same position as the crucible gave the reading mentioned above.

As will be seen, the results obtained by this treatment agree closely with the calculated amounts of acid sulphate which

* Chem. News, viii, 243.
† This Journal, viii, 460.
‡ Jour. f. prakt. Chem., cii, 131.

should be formed. In several experiments this salt was dissolved in water and the sulphuric acid present in combination precipitated by barium nitrate. The results obtained agreed closely with the formula of the acid sulphate of thallium. Having obtained by the method described the acid sulphate, the crucibles were removed and heated carefully over a free flame to low redness, when, after a considerable evolution of sulphuric acid fumes, the weight again became constant, and the results showed a condition closely approximating to that of the neutral sulphate. In several of these experiments the sulphuric acid present in combination was determined and showed amounts closely agreeing with the constitution of the neutral sulphate.

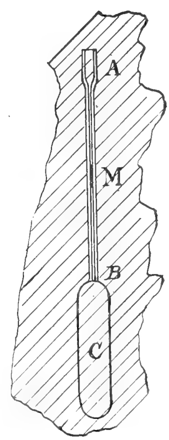
	$TlHSO_4$ calculated. grm.	$TlHSO_4$ found. grm.	Error. grm.	Tl_2SO_4 calculated. grm.	Tl_2SO_4 found. grm.	Error. grm.
1	0·1605	0·1596	0·0009 −	0·1344	0·1346	0·0002 +
2	0·1611	0·1608	0·0003 −	0·1349	0·1346	0·0003 −
3	0·1608	0·1608	0·0000 ±	0·1347	0·1352	0·0005 +
4	0·1612	0·1600	0·0012 −	0·1350	0·1346	0·0004 −
5	0·1602	0·1596	0·0006 −	0·1341	0·1346	0·0005 +
6	0·1608	0·1596	0·0012 −			
7	0·1617	0·1604	0·0013 −			
8	0·1608	0·1592	0·0016 −	0·1347	0·1358	0·0011 +
9	0·1609	0·1590	0·0019 −	0·1348	0·1346	0·0002 −

These results would seem to show that thallium may be estimated either as the acid sulphate or as the neutral sulphate by careful attention to the proper conditions of temperature.

Art. XIV.—*The Motion of a Submerged Index Thread of Mercury in the Lapse of Time;* by C. Barus.

1. If a short thread of mercury M is used under water as an index in the vertical stem of a bulb B, it is a common observation to find that the mercury will gradually creep downward into the bulb. Thus to take the case of an old Oersted piezometer bulb (capacity 35^{cm^3}) surmounted by a stem $0{\cdot}1^{cm}$ in diameter internally and exposed to variations of atmospheric temperature, the positions of the mercury meniscus were (neglecting intermediate observations)

				Top meniscus	Bottom meniscus
1896, Feb.	8	9^h	Temp. 17° C.	$1{\cdot}2^{cm}$	$3{\cdot}8^{cm}$
	9	10^h	14°	3·1	5·7
	10	10^h	15°	2·5	5·1
	11	15^h	19°	2·1	4·7
	12	12^h	17°	2·9	5·5



Since the thread returns to the same temperature on the 12th as on the 8th of February, 1896, the motion of the thread downward during the intervening 4 days and 3 hours (say 100 hours) was $1{\cdot}7^{cm}$.

From this it apparently follows that there must be leakage of liquid around the mercury and that a thin cylindrical shell of liquid may be sought for, between the thread of mercury and the inner wall of the glass stem. The viscosity of mercury being larger than that of water, this motion will persist in the main by shearing the shell of water in question. Under these circumstances (accepted as a first hypothesis) the condition of motion may be computed.

Let r be the radius of the tube, δr the thickness of the shell of water subjected to a cylindrical shear. Let l be the length of the thread of mercury, t the time in which the thread creeps down the length δl. Then the tangential stress shearing the film is per unit of area $\pi r^2 l\, 13{\cdot}6\, g/2\pi r l = 6700\ r$ nearly, when g is the acceleration of gravity. On the other hand, the rate at which the shear is increased is in the same *c.g.s.* units $\delta l/t\delta r$. Therefore if η be the viscosity of water at 20° (about ·01 say),

$$\delta r = \eta\ \delta l\,/\,6700\ tr = {\cdot}0000015\ \delta l\,/\,tr, \text{ nearly.}$$

In the above piezometer $\delta l = 1{\cdot}7^{cm}$, $r = {\cdot}05^{cm}$, $t = 36\times10^4$ sec. Hence $\delta r = 1{\cdot}4\times10^{-10cm}$. If, therefore, the film were uniform,

and of the normal viscosity of water, its thickness would have to be much below even the diameter of the molecule of water.

This surprising result shows that the conditions assumed are not given. If water contributes to the motion, it must do so with so thin a film as to possess a viscosity enormously greater than the normal η assumed, or in other words, the difference between superficial and internal viscosity is here paramount. Again the result is a mixed phenomenon and it must be the object of experiment to disentangle the part played by capillarity from the part due to viscosity.

2. When in a room of variable temperature the thread of mercury is moved up and down in consequence of the thermal expansion of the water in the bulb, the effect is a tendency to moisten the tube or keep up a supply of water between mercury and glass. In the absence of such motion the film will gradually be squeezed out between mercury and glass whereupon the thread of mercury will hermetically seal the contents of the bulb. One would expect, therefore, that if the liquid is kept at constant or very slowly varying temperature, the mercury thread will be stationary. To test this I placed the above piezometer in a space of approximately constant temperature (i. e. varying very gradually from season to season). The results obtained were

1896, Feb. 14	Temp. 14·5° C.	Top 4·4^{cm}	Bottom 7·0^{cm}	Reduced mean position at 14° C. 5·9^{cm}
17	14·2	4·4	7·1	5·8
23	13·0	4·9	7·6	5·8
Mar. 15	14·5	5·3	7 9	6·8
Apr. 19	16·0	4·9	7·5	7·0
Aug. 5	19·9	5·2	7·8	8·9
1897, Feb. 6	14·0	13·0	Lost	14·3

Comparing this table with the last, it is seen that between Feb. 8, 1896, and Feb. 6, 1897, both at 14° C., the descent is about 12^{cm} for the year. The mean rate of descent for the year, however, is but ·0014^{cm} per hour as compared with ·017^{cm} per hour at the outset. Indeed, if the mean positions of the thread be reduced to a common temperature (see table), the curve obtained indicates an initial retardation of motion with time, succeeded by a marked acceleration of the motion on passing through the region of high summer temperatures; although the thread is but 2·6^{cm} long and the bulb quite submerged, some reason already exists to lead one to suspect viscous dilatations of the bulb.

3. At the circular edge of the meniscus three surfaces meet, and the difference of surface tensions of mercury-glass and water-glass must be equal to the resolved part of the surface tension of mercury-water. In other words, the resultant of surface tensions is normal to the glass surface at the edge in

question, thus admitting of a considerable contact angle. I am unable, however, to find satisfactory data for the stresses in question; but it is probable from the large values of surface tension involved that the rate at which water is withdrawn between mercury and glass is more rapid than the motions of the thread instanced above. The problem, therefore, now assumes a somewhat different form, namely, to so wet the glass by moving the mercury thread as to favor a supply of film between mercury and glass. I tried many methods to accomplish this. They were all negative as to results, and I will, therefore, merely describe one. The capillary tube AB (above figure), $\cdot08^{cm}$ in diameter, surmounted by a cistern A, was provided at its lower end with a bulb C ($1\cdot2^{cm}$ in diameter, $4\cdot5^{cm}$ long), large enough to displace the thread M throughout its length (about $3\cdot5^{cm}$) by reasonably heating the bulb in water baths (18° to 40°). A millimeter scale was attached to the stem and read off with a telescope. The tube was first placed in a special water bath of constant temperature (about 18°), and the position of the thread taken while a sensitive thermometer indicated the temperature of the bath. The tube was now removed and submerged successively in the two auxiliary water baths in question. In this way the thread was kept in continual motion at an average rate of about a centimeter in 10 sec., the operation being prolonged throughout 3,000 seconds. Finally the tube was returned to the normal water bath and the position of the thread read off at the temperature given by the sensitive thermometer. The bulb itself showed about $\cdot2^{cm}$ per degree C, thus admitting of corrections. The results indicate a fall of less than $\cdot05^{cm}$ for the 3000 seconds of motion. Inserting the superior limit in the above equation, a film having average thickness of $\delta r < 6 \times 10^{-10cm}$ is deduced, in spite of the continued motion of the thread. This result, as absurdly small as the corresponding datum in § 1, shows the effect of motion of the kind applied to be insignificant.

4. Finally the endeavor was to be made to study the effects due to the volume viscosity of glass. The bulb of the above piezometer being 35^{cm^3} in capacity, a promising method would consist in reducing the volume to a very small value. Accordingly two tubes (Nos. II and III) with bulbs $\cdot25^{cub\ cm}$ and $\cdot40^{cub\ cm}$ in capacity, and stems respectively $\cdot1^{cm}$ and $\cdot2^{cm}$ in diameter, were selected. These were filled with pure water and a short thread of mercury ($4\cdot7^{cm}$ and 4·2 long in the two cases), inserted under water near the open ends of each. The tubes were now provided with glass millimeter scales and a thermometer, and then completely submerged in pure water contained in a long stand glass, closed with a rubber cork.

Observations of the lower and upper meniscus of each tube were taken from time to time in the course of about 4 years. Though placed in a vault, the seasonable variations of temperature could not be excluded. Change of temperature, however, was very gradual, and in view of the small bulbs and wide stems, the mercury thread was but slightly shifted. The data are recorded in the following table, and for brevity the mean positions of the threads (point midway between the upper and lower meniscus) need only be given, as observed before and after April 19, 1896.

Time.	No. II.	No. III.	Temperature.
1896, Feb. 17	$-\cdot13^{cm}$	$-\cdot05^{cm}$	16° C.
Feb. 23	$-\cdot10$	$-\cdot05$	15
Mar. 15	$-\cdot03$	$-\cdot03$	17·5
April 19	$\pm\cdot00$	$\pm\cdot00$	19
Aug. 5	$+\cdot07$	$+\cdot11$	22·7
1897, Feb. 6	·24	·31	15·8
1899, Dec. 12	·92	·70	19·0

The mean positions are referred to an arbitrary cm. scale reading downward. Since the effect of temperature is slight, both series may be plotted to show their variations in the lapse of time. The data are found to be regular and consistent throughout the whole time of nearly 4 years. The larger thinner thread II shows more rapid motion than the shorter thicker thread III. Both move at a regularly retarded rate through infinite time, and there can be no further doubt that the cause of motion is the volume viscosity of the bulb, which is thinner and sustains slightly more pressure in case of II than in case of III. Taken together, the present rates under like conditions are strikingly less than the rate of motion for the above large piezometer bulb, which is again in accord with the more effective conditions for exhibiting volume viscosity in tbe latter case. Between April, 1896, and December, 1899, at 19° C., the mean motions of the threads were but 29×10^{-6} per hour for II and 22×10^{-6} per hour for III, as compared with the rates 17000×10^{-6} per hour and 1400×10^{-6} per hour (above, § 2), for the large bulb.

5. I was not prepared for the above results, not supposing that the viscous volume expansion of a totally submerged cold glass bulb, resulting from the pressure excess of a thread of mercury but $2{\cdot}6^{cm}$ long, would be of such marked value. Moreover this thread is filled in under water and in all cases retains a moist appearance, which may, however, only mean a clean surface of contact. Obviously, however, the surface viscosity of water, i. e. the change of viscosity with diminishing thickness of film can not be observed in this way. For the case of thin oils with small surface tension I am by no means sure that the case is hopeless and I have accordingly arranged a series of tubes with this end in view.

Brown University, Providence, R. I.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the third Radioactive substance in Pitchblende.*—In the belief that other radioactive substances occur in uraninite besides polonium and radium, Debierne, at the suggestion of M. and Mme. Curie, has made a further examination of this mineral in the laboratory of the Sorbonne; giving especial attention to those substances whose acid solutions are not precipitated by hydrogen sulphide, but which are completely precipitated by ammonia and ammonium sulphide. The crude material employed came from an Austrian chemical works where uranium compounds were made from pitchblende, and hence contained these compounds only in small quantities. Since the quantity of radioactive substance was very small, even in this residue, the several hundred kilograms used were first treated so as to eliminate polonium and radium as completely as possible. The larger portion of the ammonia precipitate was made up of alumina and iron oxide, though zinc, manganese, chromium, vanadium, uranium, titanium, columbium and tantalum were also present in minute quantities, as were also lanthanum, didymium, cerium and the yttrite earths. As the other elements were successively separated, the new substance became concentrated, the portion containing the titanium and its analogues showing radioactivity very intensely. A product was finally obtained giving the principal reactions of titanium, but which emitted extremely active rays, a fraction, by a rough determination, being estimated to be a hundred thousand times more active than uranium. While its chemical properties are entirely different from those of polonium and radium, its radiations are entirely comparable to those given out by these elements. They discharge electrified bodies, they excite phosphorescence of a barium-platinocyanide screen and they act on the photographic plate. The new substance, however, is not self-luminous, as Mme. Curie has shown radium to be.—*C. R.*, cxxix, 593, October, 1899. G. F. B.

2. *On the Spectrum of Radium.*—Having received at various times from M. and Mme. Curie specimens of barium chloride containing radium in progressively increasing quantities, Demarçay has submitted these to spectrum examination and finds not only that with the increase of radio-activity the line of wave length 3814·8, observed by him a year ago, becomes stronger, but that new lines also make their appearance. In the last specimen examined the radio-activity was about $1·7 \times 10^4$ times that of uranium. Its spectrum was photographed in the ordinary way and was found to contain lines between wave lengths 5000 to 3500. This spectrum showed (1) a very intense and complete spectrum of barium; (2) the spectrum of the platinum electrodes

and of certain impurities, such as calcium and lead, the lines being very weak; and (3) fifteen new lines belonging to radium, some of which are as strong as the brightest barium lines. These lines have the following wave lengths, the numbers appended being the intensities, 16 being the brightest and 1 the feeblest: 4826·3 (10), 4726·9 (5), 4699·8 (3), 4692·1 (7), 4683·0 (14), 4641·9 (4), 4627·4 about, (4), 4600·3 (3), 4533·5 (9), 4458·0 about, (3), 4436·1 (8), 4364·2 (3), 4340·6 (12), 3814·7 (16), 3649·6 (12). At 4627·4 and 4458·0 are the centers of nebulous bands, the latter being the weaker. The lines are sharp and fine and recall those of barium. Other lines were observed, a dozen or more in number, but very faint. They will be measured when the radium is further purified. The author is now examining the less refrangible region.—*C. R.*, cxxix, 716, November, 1899. G. F. B.

3. *On the Atomic Mass of Radio-active Barium Chloride.*—Experiments have been made by Mme. CURIE to determine the atomic mass of the metal existing in the successive products of purification of the radio-active barium chloride. Two kilograms of this active chloride, extracted from half a ton of uranium residues were submitted to fractional crystallization, the activity being concentrated in the least soluble fractions. The chloride thus obtained was fractionally precipitated with alcohol. The most active material was contained in the precipitated portions. The atomic mass was determined in the anhydrous chloride in the usual way by precipitating the chlorine with silver nitrate. Each of these determinations was accompanied by a similar determination on inactive chloride, as a control. The radio-activity was simultaneously determined by measuring the current flowing between the two plates of a condenser 8^{cm} in diameter placed 3^{cm} apart, the differences of potential between these plates being 100 volts. The active material occupied a circular space 2^{cm} in diameter on the lower plate. The current produced by metallic uranium under these conditions is $0·25 \times 10^{-11}$ ampere. With the successive fractions the following values were obtained:

$i \times 10^{-11}$ amperes	a	m	Ba
750	3000	140·0	138·1
1170	4700	140·9	137·6
1870	7500	145·8	137·8

Here i represents the current passing, a the radio-activity thus measured in terms of uranium taken as unity, m the atomic mass of the metal in the active chloride and Ba that of the metal in the inactive chloride used for comparison. It will be observed that a notable difference exists between the atomic mass of the active chloride and that of the ordinary chloride; and further that as the radio-activity increases, the atomic mass becomes greater also. Taken in connection with the spectrum results obtained by Demarçay as given above, it would seem that radium has a right to recognition as an element. The substances above measured were fractions examined at once after their preparation.

But it should be noted that the radio-activity of all these fractions, whether produced by crystallization as in the case of the chloride or by precipitation as in that of the sulphate and carbonate, increases very rapidly for several days after assuming the solid form; attaining at the end of some weeks in the case of the very active fractions a limiting value which may reach even five or six times the initial one. Experiments have not yet been made to fix the atomic mass of the substance used by Demarçay—which was 17000 times more active than uranium—for want of material. Evidently the atomic mass of radium is higher than that of barium.—*C. R.*, cxxix, 760, November, 1899. G. F. B.

4. *On Chemical Effects produced by Becquerel Rays.*—A yet more remarkable effect of the Becquerel rays has been noticed by M. and Mme. CURIE. They find that these rays emitted by very strongly radio-active barium salts are capable of transforming oxygen into ozone. When such a salt is preserved in a stoppered bottle, for a short time, there is perceived on opening the bottle a distinct odor of ozone; a fact first noted by Demarçay with the sample of active barium chloride sent him for his spectroscopic work. With the bottle open the odor is dissipated almost completely. But if the bottle be closed it regains its primitive intensity in ten or fifteen minutes. The production of ozone in this way was verified by the authors by means of iodide of starch paper which, placed before the mouth of the bottle, was distinctly colored. The tint is darker if the active substance is placed directly on the paper. Ordinary barium chloride produces no effect under these conditions. The radio-active substances required to produce this ozonizing effect are all very active and very luminous. But the effect seems more directly connected with the radio-activity than with the luminosity; a radium carbonate, though very luminous, producing less ozone than a radium chloride, much less luminous though more strongly radio-active. An analogous action of the Becquerel rays upon glass has also been observed by the authors. If a sample of a radium salt be preserved for a long time in a stoppered bottle, a violet coloration appears inside the glass and passes gradually through to the outside. With a very active material, the bottom of the bottle appears almost black in the course of twelve days. Even barium platinocyanide, when exposed to the action of radium, begins to turn first yellow and then brown, losing its power of phosphorescence; though by exposure to sunlight this power may be recovered. This yellowing effect can take place even through a plate of aluminum. If such a plate covered with the platinocyanide be placed above a radio-active salt, in the dark, the platinocyanide phosphoresces at first strongly, but gradually becomes brown and loses its brightness. But now if it be exposed to light the platinocyanide is partially regenerated, so that it now shines in the dark; thus showing the synthesis of a phosphorescent body of long duration by means of a fluorescent body and a radio-active one. Even crystals of the radiobarium

chloride, deposited from a hot saturated solution on cooling, which crystals are colorless, assume gradually a rose color; this color being assumed the more rapidly as the substance is more strongly radioactive. Since the transformation of oxygen into ozone requires a consumption of energy, the above production of ozone seems to prove in these rays a continuous evolution of energy.—*C. R.*, cxxix, 823, November, 1899. G. F. B.

5. *On the Chemical Action of X-Rays.*—The interesting results of M. and Mme. Curie just given have led VILLARD to publish some similar observations noticed sometime ago with X-rays. When a Crookes tube has been in use for some time the glass, as is well known, becomes violet in color in that portion above the plane of the anticathode, i. e., on the spot where it receives the cathodic rays. This region is struck both by the cathodic rays and by the X-rays simultaneously. To determine which produces the effect, the author surrounded the anticathode of a focus tube with a large glass tube, the interior walls of which could be protected against the cathode rays by a very thin plate of aluminum which is very transparent to the X-rays. A silhouette in opaque metal, as platinum for example, could be interposed in the path of these rays. After a half hour of action, the author observed that when no aluminum was interposed, the tube, if of flint glass, blackened strongly taking a bluish tint with a metallic luster; while if of ordinary glass it became simply brown; both being cases of ordinary cathode reduction such as is produced in a reducing flame. If the aluminum be interposed, however, it arrests the cathode rays and suppresses this reduction completely; and now only a violet coloration is developed, equally with both kinds of glass. This effect is evidently due to the X-rays. It is produced only above the plane of the anticathode and if a small plate of platinum be interposed, the protected region remains colorless. This phenomenon is certainly one of oxidation, the violet color being due probably to manganese. It establishes an interesting relation between X-rays and Becquerel rays.—*C. R.*, cxxix, 882, November, 1899. G. F. B.

6. *On the new Element Victorium.*—By means of long continued fractionations, by fusion and partial decomposition of the nitrates, by crystallization of the oxalates and by precipitation with potassium sulphate, resorted to in succession, CROOKES has succeeded in isolating from the earths of the cerium and yttrium groups a new element which he has called *victorium.* Victoria is an earth of a pale brown color, easily soluble in acids and less basic than yttria. If the oxide be assumed as Vc_2O_3, the atomic mass of victorium is about 117. The best material for obtaining its phosphorescence in a vacuum tube is, not the earth itself, but the anhydrous sulphate. The spectrum contains a pair of strong lines at 3120 and 3117 and fainter ones at 3219, 3064 and 3060.—*Proc. Roy. Soc.*, lxv, 237–243, 1899. G. F. B.

7. *The Elements of Physics*, for use in High Schools. By HENRY CREW, Ph.D., Professor of Physics in Northwestern

University. 8vo, pp. xiv, 347. New York, 1899. (The Macmillan Company.)—The starting point of this book, as the author tells us in his preface, is the essential unity of the Science of Physics. Being the science of matter and energy, its various subdivisions should obviously be so presented that the student passes by easy and natural steps from one to another, recognizing continually the great fact that while energy is conserved, it appears in various forms and gives rise to various phenomena. An examination of the book seems to show a good measure of success in this direction. The plan is excellent and quite novel for an elementary manual. The classification is good, the treatment of the subject is clear and exact, the illustrations are fresh and well selected. We think that Dr. Crew has produced a text-book which will not only render a service to the grade of schools for which it was written, but will find a place in other and higher institutions. G. F. B.

8. *Modes Opératoires des Essais du Commerce et de l'Industrie.* Leçons pratiques d'analyse chimique faites aux Laboratoires Bourbouze. Par L. Cuniasse et R. Zwilling, Chimistes-Experts de la Ville de Paris. Avec preface de M. Ch. Girard, Directeur du Laboratoire Municipal. 12mo, pp. viii, 302, Paris, 1900. (Georges Carré et C. Naud).—An analytical manual of commercial chemical analysis, giving the methods followed in the Bourbouze laboratory of the City of Paris. It is divided into two parts, the first treating of mineral analysis, the second of the analysis of organic substances. The methods seem to be well selected and clearly described. And the range of subjects treated is very considerable in view of the size of the volume. It will prove of much use to students in industrial chemistry, as the processes are modern and the details are well worked out.

G. F. B.

9. *Radioactive Substances.*—M. Henri Becquerel has studied the phosphorescent effect of the radiation of radium. This substance was mixed with a few milligrams of barium chloride and the radiation was directed upon calcium, strontium sulphides, and rubies, diamonds, calc spar, fluorite, and hexagonal blende in a Becquerel phosphoroscope. It was found that all substances which became luminous under the X-rays also showed phosphorescence under the radiations from radium. A species of diamond which was very luminous under these radiations did not become luminous under the effect of the X-rays. Similar differences were observed with other substances. The author concludes that there is a loss of energy by radioactive substances.—*Comptes Rendus*, Dec. 4, 1899, pp. 912–917. J. T.

10. *Deviation of the Becquerel rays in the magnetic field.*—F. Giesel shows that these rays are deviated by magnets. A preparation of polonium was the source of the rays. Radium also showed the same phenomenon but not to so high a degree.—*Wied. Ann.*, No. 12, 1899, pp. 834–836. J. T.

11. *Velocity and susceptibility to magnetic action of the Cathode rays.*—In the same field which Professor J. J. Thomson has worked,* E. WIECHERT has made an elaborate investigation and believes that the discoveries of Lenard and Röntgen show the existence of an electrical atom of smaller dimensions than the chemical atom. This electrical atom has a negative charge. It is reasonable to suppose also that there are positive atoms of corresponding size. The deviation of the cathode rays by magnetic influence seems to the author far greater than if they consisted of streams of ordinary chemical atoms. On the emission hypothesis, therefore, it is necessary to suppose atoms of smaller size. The method of experimenting consisted largely in the use of Lecher's arrangement of circuits for determining wave lengths of electrical oscillations. A table of the values of the velocity v of the negative atoms is given in comparison with the velocity V of light. From this table it appears that the velocity v is about $\frac{1}{5}$ of that of light. The ratio of the electrical charge to the mass of the atom is of the order $4{\cdot}64.10^{17}$ or $3{\cdot}04.10^{17}$.—*Wied. Ann.*, No. 12, 1899, pp. 739–766. J. T.

12. *On the limits of hearing.*—R. KOENIG continues his investigations* of the upper limit of hearing and discusses the applicability of different methods of study. These methods consist in the use of rods vibrating transversely, rods vibrating longitudinally, vibrating plates and organ pipes, strings and membranes. By the use of Kundt's dust figures, the notes of tuning forks from c^{*} to above f^{v}, or to 90,000 vibrations, can be determined with great accuracy. Strings and membranes are unsuitable for the determination of high notes. The paper concludes with a full summation of the results obtained.—*Wied. Ann.*, No. 12, 1899, pp. 721–738. J. T.

13. *Method of showing periodic current curves.*—Two papers have appeared on this subject in which the deviation of the cathode rays by an electromagnet is employed as the method of measurement. A bundle of cathode rays forms a luminous spot on a fluorescent screen and the position of this spot moves as the bundle is deviated periodically by the influence of an electromagnet. In fact this bundle constitutes an index of no weight and is well calculated to exhibit the periodical changes of the current which excites the electromagnet. The method is due to F. Braun (Wied. Ann., lx, p. 553, 1897). It is elaborated by J. Zenneck. The same number of Wiedemann's Annalen also contains a paper on the same method by A. WEHNELT and B. DONATH, who described a simple arrangement of the Braun cathode tube in combination with a photographic camera. The method is applied by the last-named writers to an investigation of the Wehnelt electrolytic interrupter, and they conclude that the Braun tube is suitable for quantitative measures of current and electromotive force curves.—*Wied. Ann.*, No. 12, 1899, 861–870. J. T.

* See this volume, p. 66.

II. Geology and Natural History.

1. *The Geological and Natural History Survey of Minnesota*, N. H. Winchell, State Geologist. *The Geology of Minnesota*, Vol. IV of the final report; by N. H. Winchell assisted by U. S. Grant, J. E. Todd, W. Upham and H. V. Winchell. St. Paul, 1899.—This volume deals with the geology of the northern third of the State of Minnesota, including all the counties bordering on Lake Superior and on the international boundary, as well as the great iron-producing sections of the State. The region to which it is devoted is an absorbingly interesting one. The interest is located at the two extremes of the geological scale. With the exception of a few scant remnants of a once extensive Cretaceous formation, all the older rocks of the region belong to the Archean or to the overlying Animikie and Keweenawan which are together designated by Winchell as "Taconic" contrary to common usage. Upon the glacially abraded surface of these older formations lies the late Pleistocene drift, and imposed indifferently upon the drift and older rocks are the features of the Glacial and post-Glacial lacustrine occupation. There are thus two classes of geologists who will be especially interested in the volume, viz: those who have worked in pre-Cambrian geology and those more particularly concerned with the problems of the Pleistocene. Of the thirty-two chapters contained in the volume six are devoted to Pleistocene and Recent geology, two by Upham and four by Todd. The last chapter of the volume is by H. V. Winchell and deals with "Minnesota Iron Mining, economically and statistically considered." The remaining twenty-five chapters deal chiefly with the geology of the older rocks. Thirteen of them are written by N. H. Winchell and twelve by Grant. The volume is large and important in appearance and has the attractiveness which graphic representations give to otherwise tedious geological descriptions, there being no less than 31 geologically colored plates, 48 photo-engravings, and 114 cuts in the volume. The volume does not, however, contain as much as its size would lead one to suppose. This is due to the method adopted for the presentation of the subject matter of the volume. The first twelve chapters give a description of this portion of the State by counties. In the majority of cases contiguous counties have the same or closely analogous geological features. Each county, however, or in some instances a group of counties, is written up as if the others were a *terra incognita*. In consequence of this there is a wearisome reiteration of the same statements without any comprehensive discussion of the region as a whole. This subdivision of a scientific work along the purely arbitrary lines of county boundaries can not be condoned. It throws upon the reader the task, which should clearly devolve upon the author, of subdividing the work along natural or rational lines and so massing the facts as to afford the broadest possible view of the questions discussed. As if the itera-

tion and incoherence unavoidable in the discussion of the geology by counties were not sufficiently bad, the evil is aggravated by the separate discussion of 19 distinct areas in as many chapters, each accompanied by a geological map. These areas are scattered over the region that has just been discussed by counties, and their treatment is not more exhaustive than that of the counties. The plates are admirable and tell their story well, except that geological sections are conspicuously absent; but they should have been used as illustrative material of a general discussion of the region, not made the basis of reducing that discussion to a series of platitudes. In point of arrangement of its subject matter, then, the book is weak. There is no treatment of the region by geological provinces such as one might reasonably expect to find in a final report on the areal geology of the State. The repetition of the same theme in a long array of chapters is very wearying to the reader.

In spite of the bad arrangement of the book, however, and in spite of the peculiarly antique, even Wernerian, tone of the preface to the volume, the work has many valuable contributions to geology within its covers. These consist partly of records of observations confirmatory of accepted generalizations, often tabulated, as in the case of hypsometric and glacial data, partly of observations not yet generalized and partly of new generalizations presented presumably for scientific criticism. The latter naturally make up the smallest but most important part of the report, and it is to some of these that we may address ourselves most profitably in the present brief review, leaving the data which are simply recorded, on the assumption that they have been printed for the sake of giving permanence to the record and not to invite comment.

The geology of the Archean as set forth in the report may be summarized as follows: The oldest rocks found in the region are more or less altered fragmentals and volcanics which are referred to the Keewatin. This is divided into two parts, designated as Lower and Upper Keewatin, with a well defined unconformity separating them. In the Lower Keewatin are incorporated a large volume of mica schists and feldspathic mica schists (often called gneisses) which the reviewer some years ago segregated from the Keewatin and designated the Coutchiching series. In the Lower Keewatin also are placed certain greenstones which are not regarded as altered volcanics but which (sad confession) are "supposed to represent the *cooled* original crust of the earth." This chilly proposition is thrown out nonchalantly in the preface but was probably frozen out of the body of the book as it is not further discussed. The rocks which underlie the Lower Keewatin wherever exposed, and the exposures are numerous and extensive, are granites or granitoid rocks with or without a gneissic structure, such as have been repeatedly mapped and designated as Laurentian. These granites and gneisses are intrusive in the

Lower Keewatin, so that the pre-Keewatin basement is nowhere observable, except for the above mentioned suggestions of a quite cold original crust of the earth. The base of the Upper Keewatin is marked by a well developed pebble-and-bowlder conglomerate which lies indifferently upon the Lower Keewatin and upon some of the granite which is intrusive in it.

The failure to recognize the Coutchiching as a series of metamorphic clastic strata of great volume distinct from the Keewatin is worthy of note, and arises from the difficulty, the great inherent difficulty of Archean Geology, of correlating formations on the basis of petrographical characters. The particular phase of that difficulty in the present instance is that schists similar to those of the Coutchiching, i. e., mica schists and feldspathic mica schists (gneisses so called), occur also in the Keewatin and the criteria for discriminating between the two have not yet been established. The mica schists are regarded simply as a result of the more intense metamorphism of the Keewatin. This view is advanced without attempt to explain the nature of the metamorphism which would convert the basic eruptives so characteristic of the Lower Keewatin into the very acid schists with which we are here concerned. The interesting fact comes out very clearly on nearly all the plates mapping the Archean, that there *is* a body of mica schists of very considerable volume intervening quite regularly between the greenish rocks of the Keewatin and the intrusive granites, just as is the case on Rainy Lake, where they were discriminated as a series of metamorphic sediments, which could be mapped and discussed as a constituent of the complex distinct from the Keewatin. The schists thus intervening between the greenstone of the Keewatin and the granite, although embraced in the Keewatin, are mapped in a distinct color which has, on many of the plates, a large breadth relatively to the greenstones and other constituents of the Keewatin. The fact that they are thus mapped where only the broadest kind of discrimination is attempted bespeaks for the mica schist formation an individuality and separateness such as were recognized on Rainy Lake. The fact, moreover, that the granite in several of the areas mapped comes directly against the greenstones of the Keewatin does not harmonize with the view that the mica schists are only more intensely altered portions of the Keewatin. It may be asked very pertinently, also, of the advocates of the new hypothesis whether the normal Keewatin is notably reduced in volume by the conversion of such a large fraction of it into mica schist?

It is but fair to state that Dr. Grant recognizes the Coutchiching as an individual series of the Archean complex though he complains of the difficulty of discriminating between it and the mica schists of the Keewatin. Mr. Winchell on the other hand declares that " under the term Keewatin are included all the clastics of the Archean." It seems to the writer that there is more to be gained for Archean geology in the present stage of investigation by discriminating as much as possible under as many names as may be needful for the purpose. It will be time enough to drop

out superfluous names and select our comprehensive terms, such as would embrace *all* the clastics of any part of the Archean, after a few more *final* reports have been written. When the history of the Archean has been worked out as fully as may be, the names of *all* the clastic formations comprised in it will be too numerous to refer to except by comprehensive designations and groupings, but to say that "under the term Keewatin are included all the clastics of the Archean" is simply to set up Keewatin as a synonym for Archean, which of course is not Mr. Winchell's intention.

Another point of prime importance for Archean geology is the segregation of the upper from the lower Keewatin, by the recognition of the significance of the conglomerate at the base of the upper series. The true position of this conglomerate as marking an unconformity *within* the Archean was pointed out by the writer several years ago and the work of the Minnesota Survey sustains this view. Upper and lower Keewatin certainly both antedate the great hiatus which separates the Archean from the Animikie. In this two-fold subdivision of the Keewatin we very probably have the correlatives of the upper and lower Huronian of Lake Huron, especially in the light of Coleman's more recent observations. This correlation if well founded would greatly simplify the present tangled condition of Lake Superior geology. If the upper Keewatin be the correlative of the upper Huronian, as seems to the writer extremely probable, we must relegate to limbo that far-fetched correlation of the Animikie and upper Huronian, which has become intrenched, as only error can, in the literature of pre-Cambrian geology of the past decade. It is this supposed equivalence of the Animikie and upper Huronian which has led to the remarkable attempt to pull the Huronian out of the Archean and make it a subdivision of the Algonkian. This idea once happily demolished it is to be hoped that the Algonkian will fall into its proper place in taxonomy as a designation for an assemblage of rocks between the Archean and the Cambrian, and that it will no longer like Pharaoh's lean kine attempt to fatten itself by devouring the plump and well-favored formations of the Archean.

Upon the worn surface of this Archean complex rests the Animikie in little disturbed attitudes, a purely clastic series, near the base of which occur the ore bodies of the now famous Mesabi iron range, the origin of which has been so ably discussed by Spurr in an earlier publication of the Survey. The Animikie embraces the following four subdivisions in ascending order: 1. Quartzite formation. 2. Taconite or iron-bearing formation, varying in character from hematite to a rock which has been identified as an altered greensand. 3. Black slate formation. 4. Graywacke slate formation. The trap sheets so common in the Animikie as intercalations in the formations above enumerated, which a few years ago were commonly supposed to be contemporaneous lava flows, are recognized in their true character as intrusive sills. The faulting which characterizes the Animikie in

the region of the international boundary is recognized only in a tentative way.

Upon the Animikie rests the Keweenawan, and in the discussion of this series certain new propositions of interest are advanced. It may be said in general that the Keweenawan of Minnesota is almost wholly made up of volcanics and the intrusives which traverse them, with but a small admixture of sedimentary strata. The series is thus in strong contrast to the underlying Animikie. A formation of conglomerate with sandstone or quartzite has long been recognized in the Thunder Bay region as the base of the Keweenawan (Nipigon series). The Minnesota Survey finds that Duluth gabbro, the "red rock" and certain lavas, e. g., the Beaver Bay diabase, all of which have been referred to as Keweenawan, seem to antedate the conglomerate (Puckwunge). It therefore divides the Keweenawan into two parts, viz: The Cabotian which includes all that precedes the conglomerate and the Manitou including the conglomerate and later formations. In making this discrimination Mr. Winchell is evidently in a quandary whether to put his Cabotian in the Animikie or keep it in the Keweenawan. He expresses his opinion that the Animikie graded gradually into Keweenawan, and that in the Keweenawan there was a profound erosion interval represented by the Puckwunge conglomerate. This seems to the writer an indefensible position to assume. The logical thing to do is to place anything that grades into the Animikie and antedates such an unconformity into the Animikie. But it is not at all clear that any such reconstruction of the Animikie is necessary. It does not seem, for instance, to be at all satisfactorily established that the Duluth gabbro antedates the conglomerate. No pebbles of the gabbro have apparently been found in the conglomerate. The fact that the gabbro is inferior in position to the conglomerate is of no weight, since the gabbro is admittedly intrusive. The "red rock" pebbles are not necessarily derived from gabbro contacts. Mr. Winchell assumes that the Logan sills and dikes in the Animikie are offshoots from the gabbro intrusion, but this is shown to be improbable on petrographic grounds by Dr. Grant; and some of these sills and dikes have "red rock" contacts. The Duluth gabbro cannot be earlier than the Puckwunge conglomerate and at the same time the equivalent of the Logan sills; for the latter are intrusive in abundance not only in the Animikie but also in Keweenawan (Nipigon) strata overlying the conglomerate in the Thunder Bay district. It seems, moreover, that another inconsistency lies in the fact that the conglomerate is stratigraphically beneath the Beaver Bay diabase as mapped on the Cook County Plate, while the diabase is throughout the report regarded as the surface equivalent of the gabbro. Is it not entirely possible, for anything that Mr. Winchell knows to the contrary, that the Duluth gabbro was intrusive in late Keweenawan time and that some of the "red rock" of Cook County is due to the contact action of the gabbro against the Puckwunge sandstone? It is certainly remarkable, in view of Mr. Winchell's contention, that neither the geological mapping of Cook County nor the more

detailed Pigeon Point Plate shows any formations intervening between the Puckwunge conglomerate or sandstone and the Animikie; and the map is according to the writer's experience a correct expression of the relationship which prevails in the Thunder Bay district.

The relation of the Carltonian Anorthosites to the Duluth gabbro is not freely discussed in the report, but it seems to be assumed that they are the same formation. This again is inconsistent with the view that the Beaver Bay diabase is the surface equivalent of the gabbro, for the writer has shown that both at Beaver Bay and at Carlton Peak, the rocks now mapped as Beaver Bay diabase repose upon the worn surface of the anorthosite. It is futile to claim that the extensive areas of anorthosite seen under the lavas at Beaver Bay are inclusions in the lava, and the claim is reduced to an absurdity when the mountain mass of anorthosite at Carlton Peak is considered. The anorthosite is petrographically distinct from the gabbro; it shows none of the contact phenomena of the gabbro; it presents an uneven eroded surface upon which the Beaver Bay diabase, the oldest of the Keweenawan lavas, rests; the Beaver Bay diabase contains numerous included blocks of anorthosite which were evidently picked up by the lava as it flowed over the surface of the bare anorthosite, or which were detached from the walls of the vent from which the lava came to the surface; the resurrected surface of the anorthosite exposed by the removal of the lavas has the same hummocky uneven character as that which characterizes the pre-Animikie surface of the Archæan generally in the Lake Superior region; the anorthosite has a well-known equivalent in the Norian of Canada. These considerations render very questionable the correlation of the Carltonian anorthosite with the Duluth gabbro, and support the view that it is a distinct pre-Keweenawan formation.

The chapters on the counties in which the phenomena of the Pleistocene preponderate, written by Todd and Upham, and the incidental references to the same phenomena by Grant and Winchell, are important contributions to the subject, but here, again a coherent general discussion of these features, such as might be expected in a final report, would have greatly enhanced the value of the volume. The occasional summary statements by Todd and Grant are to be commended as efforts in this direction. The characters of the drift and its modifications, its special features such as kames and pitted plains, the distribution of moraines, these are all described in more or less detail; and the survey has placed students of the Pleistocene under obligations for its painstaking efforts to secure local information on these matters. The limits and shore features of Lake Agassiz are discussed especially by Todd and Grant, the shore features of Lake Warren by Grant, and the early outlet of Lake Superior as well as certain minor post-Glacial lakes by Upham. In most of the chapters there is a statement of the local features of economic interest; and the final chapter by H. V. Winchell on the iron industry is a valuable contribution to our knowledge of the great iron resources of the state. ANDREW C. LAWSON.

2. *A Revision of the Genera and Species of Canadian Palæozoic Corals, the Madreporaria Perforata and the Alcyonaria;* by LAWRENCE M. LAMBE, pp. 1–96, plates i–v, 1899. (Contributions to Canadian Palæontology, Volume IV, Part I.)—This report is particularly interesting as adding to our knowledge of the Paleozoic corals some details as to their geological range and the characteristics marking their relation to time. The author notes that the genus Favosites, when occurring in the Cambro-Silurian or Silurian, has spiniform septa whilst those of the Devonian have squamulæ. This is a confirmation of Rominger's* observation. *F. Gothlandica* is observed to occur at numerous localities in the Niagara, Guelph and Lower Helderberg formations, in divisions 2, 3 and 4 of the Anticosti Group and in rocks of supposed Hudson River age. "The only difference between *F. Helderbergiæ* and *F. Niagarensis* appears to be in the shape of the corallum which in the former species 'is large, lenticular, depressed, convex or hemispherical,' and in the latter spherical or clavate, a difference which, though slight, may be considered sufficient, if it be constant, for the separation of the two species." In discussing the genus Calapœcia, the writer has been forced to regard *C. Canadensis*, *C. Huronensis* and *C. Anticostiensis* as belonging to the same species. *Syringopora bifurcata* Lonsdale, is reported from both the Niagara and Lower Helderberg formations. In the discussion of the genus Halysites, Mr. Lambe remarks that "Particular stress has been laid on the presence or absence of septal spines by Dr. Nicholson. In his 'Palaeozoic Tabulate corals,' p. 229, it is stated that 'the form known as *H. escharoides* Lam., is distinguished from the typical *H. catenularia* Linn., not only by the superficial characters just mentioned, but also by the constant possession of spiniform septa, and the apparently constant absence of small tubes between the large ones.' This is not borne out, however, by Canadian specimens. An example from the Niagara limestone of Ontario has tubules between the corallites admirably shown as well as rows of septal spines; other examples with tubules and septal spines have been collected at Lake Temiscaming (Niagara), at Cross Lake Rapids on the Saskatchewan River and at Cedar Lake (Niagara) and from the Lower Helderberg rocks of l'Anse-au-Gascon, l'Anse à la Barbe, etc., Baie des Chaleurs. When the tubules are present and the septal spines are not seen, it is possible that the latter, on account of their small size, have not been preserved or are not sufficiently distinct to be recognized. The gradation of one form of *H. catenularia* into another would lead to the belief that it consists of one typical form with several stratigraphical varieties; the typical form not being the oldest."

From a comparative study of the Canadian specimens, he concludes, "that *H. catenularia* and its varieties range from the Black River limestone at the base of the Trenton formation up to the rocks of the Lower Helderberg Group; and that the Black

* Geological Survey of Michigan, Fossil Corals, p. 19, 1876.

River limestone in eastern Canada, the Galena-Trenton of the Lake Winnipeg region, etc., in the west, the Hudson River, Niagara, Guelph and Lower Helderberg formations have their distinctive varieties."

Three varieties of *H. catenularia* from the Lower Helderberg are described and figured under the names of var. *simplex*, var. *amplitubulata*, and var. *nitida*. An analytical table of the species and varieties, and their characters in relation to range, is also given. The genus Heliolites also ranges from the Niagara into the Lower Helderberg. Plasmopora also appears in both formations. *Lyellia affinis* occurs in the Hudson River and Niagara formations, in the four divisions of the Anticosti group, and in the Lower Helderberg. W.

3. *Geological Survey of Canada.*—The Annual Report (new series, Vol. X, reports A, H, I, J, M, S, 1897) has recently been issued in book-form, 1899, comprising 1046 pages, accompanied by 8 maps and 12 plates; separate reports of which have already been noticed. The following maps accompany the volume:

560. Thunder Bay and Rainy River Districts, Ontario—Seine Sheet.

589. Thunder Bay District, Ontario—Lake Shebandowan Sheet.

599. Nipissing District, Ontario, and Pontiac Co., Quebec—Lake Temiscaming Sheet.

606. Nipissing District, Ontario, and Pontiac Co., Quebec—Lake Nipissing Sheet. W.

4. *The Geological Society of America: Cordilleran Section.*—The first annual meeting of a Cordilleran section of the Geological Society of America was held in San Francisco, Cal., Dec. 29 and 30, 1899. The section is composed of fellows of the Society too far distant from the places of ordinary meeting of the Society to attend its sessions. The following is a list of papers accepted for reading at the meeting:

F. W. Cragin: The discovery of a goat antelope in the cave fauna of Pike's Peak Region.

J. C. Merriam: On the occurrence of a ground sloth in the Quaternary of California; On the classification of the John Day beds.

James E. Talmage: Notes concerning erosion forms and exposures in the deserts of South Central Utah.

Horace B. Patton: Thomsonite and other zeolites from Golden, Colorado.

H. W. Fairbanks: The Peneplain question upon the Pacific Coast.

W. S. Tangier Smith: A topographic study of the Islands of Southern California.

Joseph Le Conte: An early geological excursion.

J. C. Branner: The sandstone reefs of Brazil.

E. W. Hilgard: The geological significance of soil study.

E. W. Claypole: The Devonian fishes of North America.

Andrew C. Lawson: The Berkeley Hills—A detail of Coast Range geology.

W.

5. *Key to the Upper Devonian of Southern New York*; by Gilbert D. Harris, Cornell University, Ithaca, N. Y. Co-operative Society. Price 28 and 35 cents, post paid.—The "Key to the

Upper Devonian" furnishes a means by which high schools and academies can give their students field work in Geology. After a brief introduction on the kinds and occurrence of rocks and definitions of a few important geological terms, a list of a large number of localities is given with the kind of rock, location of outcrop, and some of the important fossils of each. The pamphlet closes with 120 good figures of characteristic Upper Devonian fossils. This book of thirty-five pages is admirably qualified to make this subject, which is often considered difficult and uninteresting, really enjoyable, and will bring out the powers of observation of the student. Its convenient size, advice on field work, and especially the excellent illustrations of fossils make it a very valuable supplement to the elementary text-books for students in Geology, both in the secondary schools and in colleges. H. L. C.

6. *Principles and Conditions of the Movements of Ground Water;* by FRANKLIN H. KING. With a theoretical investigation of the Motion of Ground Waters, by CHARLES H. SLICHTER. Nineteenth Annual Report, U. S. Geological Survey, pp. 59–384.—The water which falls upon the land is evaporated from the place where it falls, or drains off through natural channels or sinks into the ground. The laws and effects of the first two movements are quite well understood, but little is known of the career of the considerable portion of water which enters the soil directly and which has such an important influence in geological processes and on the industries and domestic life of civilized and uncivilized peoples. The paper of Prof. King is an important contribution to this little known subject, and gives the results of well-planned experiments and careful observations. Chapter I deals with the amount of water stored in the ground and discusses in detail the character and extent of the gravitational, thermal, and capillary movements of the waters. Chapter II is devoted to the explanation and discussion of experimental investigations regarding the flow of fluids through various porous media. In Chapter III the author discusses the rate of flow of water though sands and rocks of different character and degrees of porosity, and calls attention to the influence of this factor on wells. With Prof. King's paper is one on the Theoretical Investigation of the Motion of Ground Water, by Prof. Slichter, in which are given the physical and mathematical data for the discussion of the whole subject. H. E. G.

7. *Geologic Atlas of the United States—Absaroka Folio, Wyoming.* (Crandall and Ishawood Quadrangles); Geology, by ARNOLD HAGUE, assisted by J. P. IDDINGS and T. A. JAGGAR, JR. Triangulation and Topography, by FRANK TWEEDY, Washington, 1899.—The area covered by these sheets is that east of and immediately adjoining that of the Yellowstone Park and thus continues in this direction into the Absaroka Range, the work published in the Yellowstone Park Folio. The six full pages of text (equal to about 70 pp. in ordinary 8°), give an admirably

summarized account of geology, while in addition to the topographic and geologic sheets there is one of columnar sections and one of illustrations.

The sedimentaries described range upward from the Archean, but they appear only in small amount on the map to the east and north, the greater part of the area being covered with volcanic ejections, breccias and flows cut in places by great numbers of dikes and pierced by intrusive masses. They range from rhyolites through andesites to basalts, the andesites of various types being especially prominent. These outbreaks took place over an already eroded country in Eocene and Neocene time. The erosion since then of these great masses of rather easily degraded material has resulted in most interesting and peculiar types of topography.

L. V. P.

8. *Preliminary Notice of the Etcheminian Fauna of Cape Breton;* by G. F. MATTHEW, LL.D., St. John, N. B., Canada. Nat. Hist. Soc. N. Bruns'k. Bull. XVIII, vol. iv, pp. 198.—This paper gives an account of the fossils found in Cape Breton, Nova Scotia, in a set of beds forming the lowest Paleozoic terrane in that province. The forms described are all either brachiopod or ostracod, and while the genera correspond to those of the Protolenus Fauna (Cambrian) in New Brunswick, the species are all different.

The forms described belong to the brachiopoda and ostracoda. Of the former new species are described belonging to the genera Lingulella, Leptobolus, Obolus, Acrothele and Acrotreta; the Obolus is said to belong to a new sub-genus (Protobolus) characterized by the approximation of the vascular trunks in the ventral valve.

The Ostracoda are all small and are referred to two genera, Bradoria (new) and Schmidtella.

The article is accompanied by four plates of figures and two sections to show the relation of the Etcheminian terrane to the formations above and below.

9. *Recent Foraminifera.* A Descriptive Catalogue of Specimens dredged by the U. S. Fish Commission steamer Albatross; by JAMES M. FLINT, M.D., U. S. N., Honorary Curator, Division of Medicine, U. S. National Museum. (From the Report of the U. S. National Museum for 1897, pp. 248–349, with eighty plates. Washington, 1899.)—The purpose of this catalogue, as stated in the preface, is to record the additions to our knowledge of the Foraminifera obtained by the deep-sea dredgings of the Albatross. In order to show its place in the literature of the subject it may be well to compare it with Brady's classic report on the Foraminifera collected by the Challenger expedition.

The latter consists of 814 pages and 145 plates, comprising an introduction discussing the chief problems presented by this group of Protozoa, followed by a bibliography, a new classification, and the detailed descriptions of genera and species. At the close of the Challenger report are tables showing the distribution

of certain species, in area, in depth, and over diverse bottoms. Finally, there are maps giving the location of the two hundred and eight stations which furnished material for the examination.

The majority of Foraminifera are of such world-wide distribution that, although the soundings are few compared to the vast area of the oceanic basins, large portions of which are still entirely unexplored, new expeditions will not greatly increase the number of species, but will rather give more precisely their areal limits and dependence upon environment. It is in these respects that the Albatross report has its chief value, yet it embraces many features which make it the most important contribution to the subject since the Challenger report of 1884. The latter included the results of one hundred and forty stations observed by the Challenger naturalists, twenty-four of these being in the north Atlantic, with sixty-eight recorded by other expeditions from points surrounding the British isles, and in the Arctic ocean. The present report, on the contrary, includes observations from ninety-two stations, of which fifty-eight are from the north Atlantic, twenty-one from the Gulf of Mexico, and seven from the Caribbean sea. Into the last two areas the Challenger expedition did not go.

The title of Flint's memoir hardly indicates its value, as the report is really a volume supplemental to that by Brady. It consists of a short preface and introduction, and an analytical key to the families and genera of the Foraminifera, which to the student having only a slight knowledge of this subject should be of considerable assistance. Detailed descriptions of the families, genera, and species are then given and these are followed by the plates. The last are worthy of especial mention, being reproductions from photographs of two hundred and ninety-nine species belonging to seventy-two genera, the original specimens of which are on exhibition in the National Museum.

These photographs are to a uniform enlargement of fifteen diameters, a plan which should aid in the ready determination of species, since the size as well as the form is evident at a glance. Besides being clear and sharp, the reproductions are characterized by a striking relief and truthfulness. Brady's classification is adopted bodily and the species are arranged on the plates so as to best bring out their relationships.

Among the Foraminifera the transition of forms is so nearly complete that any classification into orders is bound to separate genera which are closely related. This, however, is a difficulty to be anticipated in every branch of natural history as the extinct progenitors become better known. In such cases the best ultimate solution may be to establish several basal or primitive orders, with the understanding that their boundaries are not the well-defined limits shown by the separated groups of later and better differentiated descendants. But it is not likely that a classification of the Foraminifera better than Brady's will soon be made.

The present catalogue no doubt could have been made more

valuable and complete had the author collected the scattered and missing facts regarding the environments, into tables similar to those given at the end of the Challenger report, thus showing the abundance and distribution of the species, their relation to the character of bottom, temperature of water, and vicinity to land. A map would also have been useful as indicating at a glance the location of the stations. However, the author is to be congratulated on having produced a hand-book complete in itself, yet supplementary to the work already published. It deals with nearly half the number of stations and the results are given on more than half as many plates as the Challenger report which it supplements.

For the working student it will serve as the best hand-book on the Foraminifera, yet its value is liable to be overlooked by the casual reader. J. B.

10. *Guida al Corso de Mineralogia* di ANTONIO D'ACHIARDI, Professore nell' Univesità di Pisa. Mineralogia generale, 8vo, pp. 1–339. Pisa, 1900 (Enrico Spœrri).—The author of this work is well known for his many contributions to Italian mineralogy, and for his two excellent works, one on metallic minerals and their deposits and the other on lithology. He has here given an excellent presentation of the general subject of mineralogy, including first, the morphology of crystals with a discussion of the systems of crystallization presented according to modern methods; also the physical characters, and the chemical characters of minerals. The physical characters are presented with especial completeness and system.

OBITUARY.

THOMAS EGLESTON, for many years Professor of Mineralogy and Metallurgy in the School of Mines of Columbia University, New York City, died on January 15th, at the age of sixty-seven years. Professor Egleston was born in New York City, December 9th, 1832, and was graduated at Yale College in 1854; later studies were carried on abroad, especially at the École des Mines in Paris. In 1864, largely through his efforts, the Columbia School of Mines was founded under at first very discouraging conditions. This work, which has later been followed by the development of a flourishing and highly useful institution of learning, may well be considered the most important achievement of his life. For more than thirty years, until his retirement in July 1, 1897, he held the Chair of Mineralogy and Metallurgy and was always active in promoting the progress of the School. He was also largely interested in the founding of the American Institute of Mining Engineers and its Transactions contain a number of papers by him; he also published articles in other periodicals; among larger publications may be mentioned his Catalogue of Minerals and Synonyms alphabetically arranged (Washington, 1889 and New York, 1891).

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[FOURTH SERIES.]

ART. XV.—*Hot Water and Soft Glass in Their Thermodynamic Relations;* by C. BARUS.*

1. IT is my purpose in the present address to discuss the solvent action of hot water on ordinary glass, or indeed on any silicate. That these reactions occur abundantly in nature is well known; in the laboratory, however, they are as a rule, difficult to produce in such a way as to give an insight into the quantitative relations involved. About ten years ago, I made some curious experiments which seemed to give promise in this direction. I have recently repeated and extended them, carrying out the suggestions indicated on a larger scale and with entire success. I, therefore, take pleasure in communicating the results obtained, interpreted as a whole and from a somewhat broader point of view than was originally permitted.

Among natural silicates and in a scale of increasing acidity, we are apt to find the acid rocks less fusible than the basic rocks, and the aqueous fusion may be presumed to bear a definite relation to the igneous fusion. Thus, for instance, an obsidian which Prof. Iddings and I examined, fused aqueously at about 1250°, whereas the pumice resulting did not fully fuse until about 1650° was reached. Similarly an aqueous basic silicate, fusing at incipient redness, showed complete igneous fusion at about 1200°. The effect of composition will necessarily have to be deferred until the scope of experiments like the present has been worked out, but in a laboratory attack of the subject one is more apt to reach results with the fusible

* A lecture delivered before the Physical Society of the University of Göttingen.

soft glasses than with infusible hard glasses. In all cases, of course, the glass must be quite insoluble in water under ordinary conditions of temperature. In the present experiments I worked with the common glass containing lead, of the kind from which glass rods and thick tubes are usually made, and I was further induced to select it in order that the experiments on a larger scale might be made with the identical glass of my capillary tubes. In this way the results of the quantitative experiments on a smaller scale in glass tubes could be at once coördinated with the experiments in steel retorts.

2. In view of its amorphous structure and thermal properties, one is apt to look upon glass as colloidal, and it is expedient to examine at the outset in how far such a classification is tenable. Glass as a colloid must conform to the general relations of colloids and their solvents, and one must be able to predict certain peculiarities in the behavior of glass toward water. Colloids (1) at favorable temperatures swell up enormously in the presence of their solvents; (2) at higher temperatures the swollen coagulum goes over into clear and apparently thorough solution. In other words, the coagulum melts in its menstruum, mixes with it completely at a temperature which is probably characteristic for the colloid and, so far as known, remarkably independent of the solvent chosen.

It is essential, however, to have the solvent in the liquid state. These conditions are at once fulfilled for the case of starch, of gelatine and of pure rubber, seeing that in these instances the dissolving point of the colloid lies below the boiling point of the solvent. For vulcanized rubber this is, as a rule, not the case; the usual solvents, like carbon disulphide, ether, paraffine oils, chloroform, etc., boil away before the dissolving point (about 180°) of the colloid is reached. If, however, these volatile fluids be kept liquid under pressure up to 185°, vulcanized rubber passes into clear solution as easily as starch. Still other colloids, like wood, decompose, i. e., undergo destructive distillation even when submerged in the solvent (water) under pressure, below the dissolving point.

I shall show that ordinary glass fulfills the above conditions perfectly; but before doing so a brief description of the experiments with retorts is advisable.

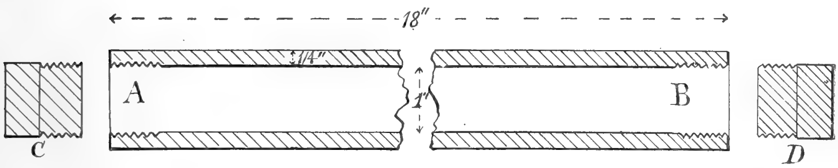
3. If water be selected as a suitable colloidal solvent of glass, the dissolving point will certainly lie above the boiling point of the liquid. Hence it is necessary to make use of high pressure retorts; and I shall take the liberty of describing a simple and efficient form which has served me not only in the present but in many similar experiments.

In the figure (1) *AB* is a piece of seamless drawn steel tubing obtained from John S. Leng, New York, about 45^{cm} long

and 2·5^{cm} in diameter, with walls ·6^{cm} thick. The interior is threaded (12 to inch) at the ends, and screw plugs are provided fitting the threads snugly (*CD*).

In order to secure a gas-tight joint for temperatures below 150°, each of the plugs is covered with a thin layer of solder in the usual way, by dipping it first in soldering salts, and then in melted solder. For temperatures below 250°, a layer of lead is applied in the same way. For temperatures above this a layer of zinc, and at red heat a layer of copper answers less satisfactorily. The copper coating is put on by dipping the hot plug in borax and then in a crucible of melted copper.

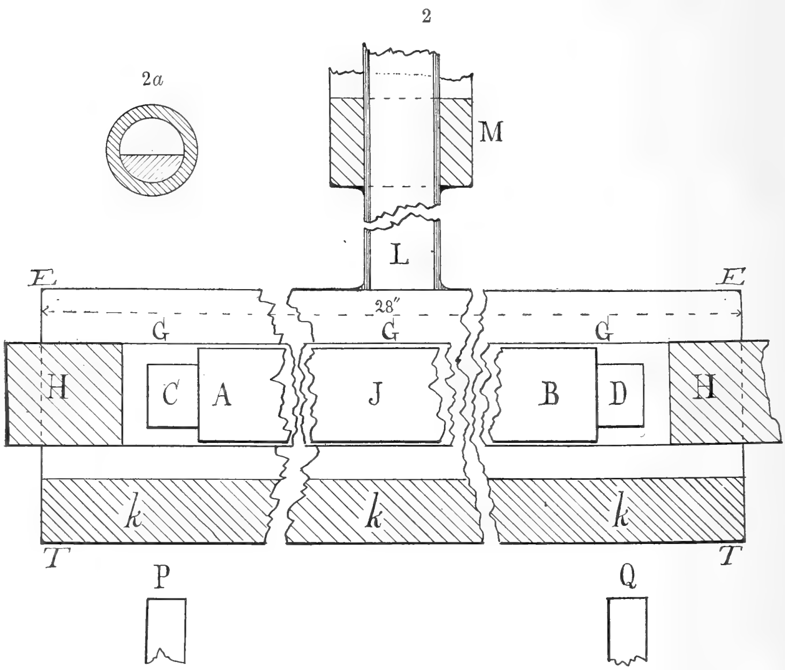
1



Unfortunately the copper is hardened by this process and I have only been able to use the screw for small diameters. Solder adheres most perfectly and less stress is needed in forcing the screw plug home. Lead, in spite of its greater softness, offers much more viscous resistance during this operation; a noteworthy result. Tubes continually used in this way are at length liable to split longitudinally, but after several hundred experiments per tube I have only had one accident of this kind. The thread is apt to suffer serious wear and tear before the tube gives out. The joint obtained as above is apparently quite gas-tight, and I have frequently heated carbon disulphide above 200° for hours, without appreciable loss. Nor is it necessary to use all the threads at once; a fresh insertion of two complete threads usually suffices, so that the screw bolt lasts throughout several experiments before requiring to be recovered. Pressures above 1000 atm. were applied without leakage.

To heat the tube to a given constant temperature, vapor baths of the form fig. 2 are available. This consists of a cylinder *ET*, 10^{cm} in diameter, 70^{cm} long, closed at the ends, except for the axially perforating eccentric cylinder *GG*. The latter is large enough to receive the retort *AJB*, snugly, and asbestos plugs, *HH*, guard against loss of heat at the ends. The vapor bath is made of sheet iron brazed together. The liquid to be boiled, *k*, is charged into the bottom of the outer cylinder, and vapors escape by a lateral vent of gas pipe

($\frac{3}{4}$ inch), *L*. By surrounding this at about two feet from the boiler with a narrow cylinder containing water, *M*, the vapors are usually condensed and flow back without giving annoyance. In the present experiments, the liquid, *k*, was naphthaline boiling at 210° and the vapor bath needed no special attention for months. If the bath is well enveloped with asbestos, except at the two patches on the bottom where the flames of two ordinary Bunsen burners, *P*, *Q*, impinge against free



metal, these are quite sufficient to maintain continuous ebullition at 210° for an indefinite time. It is well to keep *M* supplied with water by aid of some automatic dropping arrangement.

4. The charge of laboratory glass specified, being the broken capillary tubes of earlier correlative experiments, pulverized and sifted to a fine granular powder, was introduced into the retort with water. About 210 grams of glass and 50 grams of water was known to be a promising ratio. The retort was then put into the vapor bath and kept at 210° for about 12 hours.

On opening the cold retort the glass was found to be quite fused down to a resinous, opalescent, very hard and tough

body, containing white inclusions of partially converted water glass, but otherwise homogeneous. About 240 grams were removed from the retort, to which the glass adhered so firmly that a cold chisel and hammer were necessary for the process. Looking through the retort endwise, it was seen to be about one-half filled and the top surface of the glass smooth, as shown in fig. 2*a*. No excess of water was apparent, all having been absorbed. Surfaces of the glass broken from the retort were black with iron oxide.

Heated in the air above a candle flame the glass melts, swells up enormously with loss of water to a silvery white pithlike pumice. The experiment recalls the behavior of a pharaoh serpent, but is not quite so striking. On igneous fusion at red heat, the usual black lead glass is again obtained. As to hardness, water glass is not much inferior to the original igneous glass. When clear it has a different refractive index and a different density.

After exposure to the air water glass gradually disintegrates. Even after a few weeks cracks permeate the mass, and the originally solid tough block may easily be broken across. I have supposed that the combination of water and glass, stable under pressure at 210°, is unstable at ordinary temperatures, and that water set free under probably immense pressures is the cause of this phenomenon. Inasmuch as the fragments retain their property of swelling on fusion unimpaired, it is much more probable that the real cause of breakage is the gradual reaction of internal stress.

Not all kinds of glass succumb to the present treatment at 210°. The more infusible glasses are much less easily soluble. Many experiments of the present kind made with hard glass showed absolutely no cohesion or fusion when examined in the cold, even after 18 hours of exposure. Hence a higher temperature than 200° will here be needed, and the case is emphatically true for quartz. Coördinating the present experiments, in which a phenomenally low dissolving temperature is evidenced, with the results obtained from natural silicates, it is clear that every glass at a sufficiently high temperature must eventually show complete solubility in water.

Having obtained the water glass in the above form, I next endeavored, with the addition of more water, to obtain the glass in the liquid state at ordinary temperatures; but these experiments signally failed. About 180 grams of the given water glass were triturated, mixed with 50 grams of water, charged in the retort and heated for 14 hours to 210°. On opening about $10^{\text{cub cm}}$ of viscous soapy black water were taken out, floating above a black scum of glass. The substance when dry was friable and had lost the property of fusing with swell-

ing. Black stalactites, however, were seen in the tube and the edges were everywhere rounded, indicating fusion. The result of the experiment was a thorough dissociation of the charge, giving impure water and an insoluble residue of silicate. This mass was again pulverized, charged into the retort and heated for five hours. On opening the cold retort about 100$^{\text{cub cm}}$ of black soapy water were removed; the glass remained black and non-coherent. Excess of water does not, therefore, favor the present reactions.

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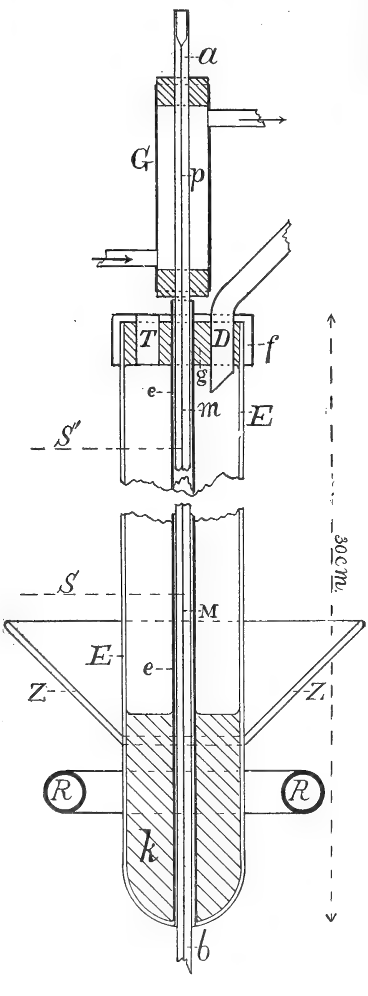

5. With these definite results in hand, we may next endeavor to inquire into the quantitative nature of the present phenomena. Having this end in view I returned to the experiments described in this Journal (vol. xli, 1891) some years ago with the new results incorporated in the present summary. To make the account intelligible it will be expedient to give a sketch of the apparatus used, the essentials of which are shown in fig. 3. Here *ab* is the capillary tube, to be cemented below into the steel flange for insertion in the compression pump. The capillary tube contains a thread of water *SS'* (lines of sight of an external cathetometer), between visible threads of mercury *m*, *M*, of which the upper one is sealed in position by a terminal thread *p*, of solid paraffine, kept cold by the jacket of circulating water, *G*. The lower mercury thread, *M*, transmits the pressure of the force pump to the water, which is thus made to react on the inner wall of the capillary tube at a definite pressure and temperature. The latter is secured by a boiling tube *EE*, of clear glass, of the kind frequently described

in my work, consisting of two concentric glass tubes, *E*, *e*, joined at the ends, the inner snugly enveloping the capillary tube *ab*. Tubulure *T* holds a thermometer. Tubulure *D* leads to the condenser, which for a charge of naphthaline at *k* (heated by the ringburner *R* and screen *Z*) is merely a long tube. Cooling in air is sufficient and the operation continuous. In experiments like the present it is convenient to join the concentric tubes *E* and *e* above, by a gas pipe cap *f*, cemented to the glass with plaster of Paris *g*. Asbestos jackets envelop the tube *E* except at the longitudinal fissures cut into them for observation. After the liquid *k* boils, the temperature of the column of vapor between the plane of ebullition and of condensation, both distinctly apparent, is constant. It is thus merely necessary to chase the latter into the condenser to obtain constancy along *SS'*.

With well annealed capillary tubes, ·02^{cm} to ·05^{cm} in diameter internally, and ·6^{cm} in diameter externally, pressures from 400 to 600 atms. are admissible. With diameters increased by water solution from ·04 to ·07^{cms} (often three times), the pressure limits are reduced; less, however, by change of diameter than by the continued stress to which the tube has been subjected.

The phenomena to be observed during the action of hot water on glass may be described as follows: During heating the thread of water expands thermally, but the expansion is partial; before the constant temperature 210° is reached the thread has begun to contract in marked degree in consequence of the corrosion. The full thread length for 210° is not reached.

The reaction itself will appear differently according as it takes place slightly below or slightly above the solution temperature. At 185° the water glass obtained is rather a coagulum. The solid swells enormously under the absorption of water, like any other colloid. It is apt to remain white and turbid, so that the progress of the mercury meniscus is seen with difficulty through the semi-translucent thread. The water glass remains elastic, i. e., it contracts and expands under the influence of pressure. Compressibility slowly but regularly increases. Contraction of the combined volume of glass and water progresses at an accelerated rate. If after long reaction (1 hour), the cold capillary be broken across and examined under the microscope, the capillary canal is found to be nearly full of an agate-like warty solid accretion. This is water glass in the swollen coagulated state.

At 210°, however, the solution temperature is exceeded. The preceding phenomenon of swelling passes rapidly into the present phenomenon of solution. The water glass gradually

becomes clear, the mercury meniscus glistens brilliantly, the thread breaks into shining globules. The white coagulum clarifies from the periphery inward toward the axis of the tube, where it gradually vanishes. Compressibility at first increasing with great rapidity to an enormous value, falls off, as it were, suddenly to the relatively low value attributable to hot water. While the reaction proceeds the solution is inelastic, i. e., the liquid fails to expand on removal of pressure. Volume decrement is at first extremely rapid, finally to vanish asymptotically in the lapse of time. The tube seen through the telescope shows an internal current continually flowing from the bottom to the top, and this current persists until the reaction terminates in clearness of tube and saturated water glass. The effect of pressure here is thus virtually an acceleration of the velocity of the current, and hence compressibility may be rated at any large value whatever, since the additional velocity imparted by pressure is now dependent on the viscosity of the flowing liquid. For this reason, moreover, removal of pressure produces breakage of thread and cavities in the viscous silicate, which in their turn swim along in the upgoing current. Cavities and mercury globules retain their relative positions to each other during the motion, though the former may often be brought to vanish by excess of pressure. I have inferred from this that the column of water glass, now two to three times the original diameter of the capillary thread of water, moves as a whole and not telescopically at a decreasing rate from the axis outward: the latter case would imply a deformation of the mercury globules which has not been observed. The mercury threads approximately retain their original diameter.

7. To obtain a clear view of the progress of the reactions here in question, the annexed chart of a typical case may be consulted, in which volumes (thread lengths in cms.) and compressibilities are laid off vertically, and the corresponding time of exposure dated from the beginning of heating, horizontally. It will be seen that 20 minutes after beginning the boiling (less than 10 minutes of exposure to 210°) the hot thread has contracted to the length of the original cold thread, and that contraction proceeds enormously beyond this. The total volume contraction of the system water and glass, as taken from the chart, would be over 30 per cent of the cold length. The observed changes of compressibility would be from about $100/10^6$ per atm., for nearly pure water, to something like $600/10^6$ for dissolving water glass. The diameter of the capillary increased from $\cdot024^{cm}$ (water), to $\cdot071^{cm}$ (water glass), upwards three times. These data were found from measurements made on sections of the cold tubes. Cf. fig. 5.

How differently a thread of paraffine behaves in a like tube at 20° and under the same conditions, is seen in the attached curve of the chart. Volume is here a slightly increasing quantity in the lapse of time, a result doubtless due to gradually increasing temperature of the vapor bath. The two phenomena are totally dissimilar. So also as I showed elsewhere, the errors of measurement introduced by the elasticity and the viscosity of the glass tube are of insignificant values as compared with the enormous compressibilities of the present investigation.

To what degree the compressibilities are real may be tested during the slower of the above reactions, at 185°, when the liquid is elastic. The compressibilities per atm. in millionths of the normal volume at the outset of the experiment were

20 to 100 atm.	100 to 200 atm.	200 to 300 atm.	300 to 400 atm.
146	144	142	146
and 15 minutes later			
188	176	201	189

the observations being throughout reliable.

At 210° the rate of reaction is far too rapid to yield results of anything like this degree of precision. A conception of the remarkably large results obtained may be secured by recalling that water and glass with compressibilities of about $100/10^6$ and $3/10^6$ at 210°, during the process of reaction show values which can only be compared with so mobile a body as liquid ether, between 100 and 200 atm. Compressing ether to keep it liquid the approximate data for compressibility are

29°	65°	100°	185°
156	207	305	741

millionths per atm., of which the two last values only are large enough to compare with the data for water glass. Yet the latter solidifies at ordinary temperatures to a hard solid, quite glassy in character.

8. The clear coagulum obtained after the reaction has subsided is again elastic, but its compressibility of minimum value probably less than that of water at 210°. Compression is accompanied with evidences of rigidity and the density of the system is a maximum. Currents have ceased. On cooling, bubbles appear in the clear column of water glass, originating at points in the axis, and growing thence centrifugally outward. The volumes in which the mercury globules were snugly imbedded at 210° now increase, until the cavity is but partially filled. As much as $\frac{1}{3}$ of an ovoid cavity may be empty. All of this points to marked contraction on solidification and cooling. The old capillaries, however carefully protected or slowly cooled, invariably break throughout their length in the lapse

of time. On casual inspection one might ascribe this result to an expansion of the solidifying core: but the occurrence of the bubbles mentioned, which open out with the great rapidity attributable only to solidification, and the fact that breakage (cf. fig. 5, *b*) is often only confined to the water glass core (being a longitudinal fissure within this, not extending to the igneous glass envelope), show that an intense strain of dilata-

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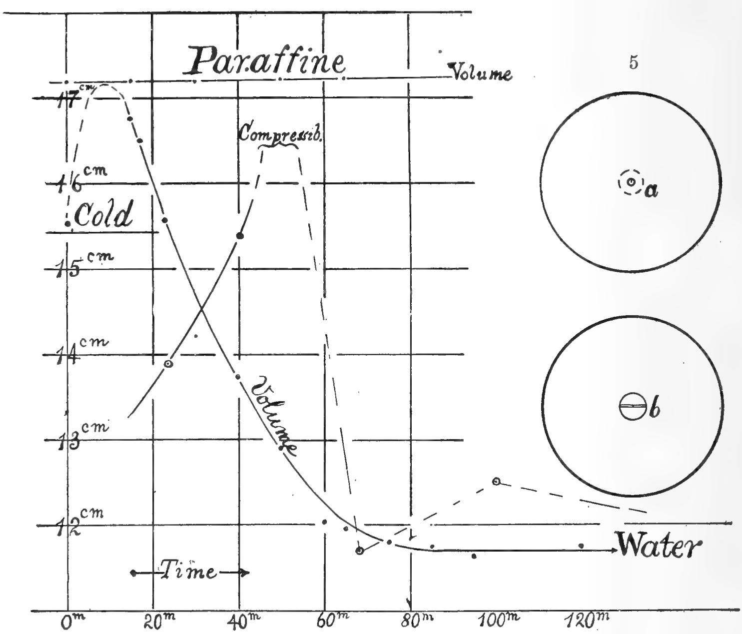

tion is encountered. All observations indicate contraction with large volume-coëfficient, too large for the igneous glass to follow. Some rough measurements of the coëfficient of expansion, the best available under the circumstances, gave between 25° and 185° a coëfficient ·0020. The mean coëfficient of water within these limits would be but ·0008. Something of this order must obtain if within a capillary section and a moderate interval of temperature, tensile stresses sufficient to rupture the tube are to be developed on cooling. But the bubbles and stresses thus resemble the occurrences which in Prince Rupert drops require so much higher a temperature to produce them.

Special mention may here again be given to the acceleration of the rate of reaction with increasing temperature. At 185° there is mainly swelling and absorption. At 210° the reaction

is already too rapid to admit of the physical measurement of its successive stages.

9. The appearance of the cold tube when cut across is enlarged in figure 5 (with fig. 4, p. 170), which shows the external and the original internal diameters, and the diameter of the core of water glass (the latter dotted). Apart from the bubbles usually connected by a very fine capillary canal, the tube has become a glass stem. On holding the tube in a suitable position, the core of water glass may be seen sharply differentiated from the igneous envelope. In other respects there is firm coherence, and the water glass appears on trial about as hard as the igneous glass. Slight heating melts the water glass, which then swells up enormously and exudes from the tube, like pith.

10. An experiment was made to test the colloidal character of the reaction by replacing the thread of water with a thread of solution of cobalt nitrate. Should the latter turn blue at 210° the occurrence of chemical reaction would be indicated. Not only was this not the case, but the reaction completing itself in the usual way, left a gray granular scum of decomposed cobalt salt in the axis of the tube. Hence all water enters the glass by diffusion, the glass itself performing the function of a *semi-permiable membrane* of the energetic character specified.

Yet the reaction as a whole cannot be represented as a mere physical diffusion: for it is not probable that the reduction of the concentration gradient from the axis of the tube outward, could result in so sharp a differentiation of water glass core and igneous glass envelope as is observed. Nor am I aware that the occurrence of contraction in a system undergoing colloidal solution, has been definitely observed or is the usual rule. Saturation is to some extent given by the swollen solid coagulate only; it is not usually observed in the colloidal solution above the melting point. In the case of water glass a definite condition of saturation at the close of the reaction must be inferred. The results above obtained with retorts in which definite quantities of water were needed to yield a clear glass, are to the point.

Since glass at ordinary temperatures does not swell up in the presence of water, the question suggests itself whether all colloids at temperatures sufficiently below their dissolving points will lose the property of swelling.

If the colloid be regarded as consisting of aggregated molecules, with all particles of nearly the same specific size but larger than the molecular diameter, the following graphic exhibit of the phenomenon of solution and coagulation is tenable. The three groups of forces involved, viz., the attraction of liquid molecules for each other, of solid molecules for each

other, and the attraction of solid and liquid molecules may be symbolized by *FF*, *SS*, and *FS*, respectively. Of these groups *FF*+*SS* together promote precipitation or crystallization, while *FS* alone is favorable to solution. The former case occurs for $FF+SS>FS$; the latter for $FF+SS<FS$. $FF+SS=FS$ for a given diameter of particle is the stable case. Suppose

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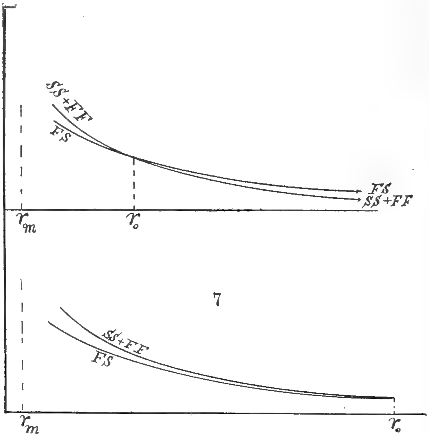

now the diameter of the particle is laid off horizontally, and the forces in question are laid off vertically. We obtain two curves which must intersect and have the relations to each other given by the figure, if a definite diameter $2r_o$ larger than the molecular diameter $2r_m$ is to be stable. For larger particles the forces *FS* are in excess and the particle will dwindle by solution. For smaller particles the forces *FF*+*SS* are in excess, and the particle will grow by accretion. The effect of temperature is to shift the curves relatively to each other, temperature increase tending to raise *SF* and to lower *FF*+*SS*, simultaneously. Recalling the colloidal condition $r_o>r_m$, the result is a motion of the point of intersection to the left and an approach of the r_o to the molecular diameter. Temperature decrease has the reverse effect, moving the point of intersection to the right. It is then merely necessary to suppose the two curves to have very nearly the same slope beyond r_o, to bring about an enormous increase in the diameter of the colloidal particle $2r_m$, for very slight thermal shifting. This is illustrated in fig. 7, and is the most natural conception I can form of coagulation. If the mass is very viscous, the condition of equilibrium will rarely be approached but very slowly. Separately considered, the curves assert that with increasing size of

particle or number of molecules to the aggregate, the attractions of particles for each other and for the liquid decrease. The nature of these forces is thus a residual affinity.

12. If again we turn to the chart, fig. 4, and inquire what will be the shape of the isotherm in a *pv* diagram, we observe that the reaction begins with the small compressibilities (large bulk modulus) of pure water, then passes through enormous values of compressibility back again to the extremely small values of compressibity at the end of the reaction. The isothermal is therefore a doubly inflected curve of the form, fig. 8, well known in the treatment of vapors. To every point of the present curve, however, there corresponds a definite concentration of water glass, increasing from right to left. The curve begins with compositions of much water and little glass, with stable solutions and elastic fluids; whatever water is forced into the glass corpuscles by pressure, comes freely and almost wholly out again when pressure is relieved. The curve terminates in compositions of much glass and little water, again stable and elastic; the intermediate field, *a*, being unstable and inelastic (non-resilient). In view of the exceedingly viscous liquids involved, the reactions are not implosive but can be observed through, from liquid water to semi-solid water glass, including the unstable part of the curve. Looking at these reactions from another point of view, they present a striking analogy to *mass action* in which either the water or the water glass is stable according as an excess of one or the other of the ingredients, water and glass, is encountered. The same inference follows from the experiments (§ 3) made in steel retorts. We have therefore traced a peculiar case of mass action evidenced by the successive values of the compressibility of the solution.

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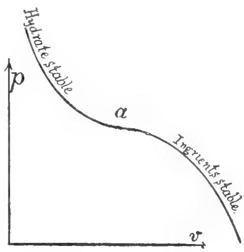

13. In the above paragraphs, I have endeavored to show that while glass expands in absorbing water, the system glass-water contracts 20 per cent to 30 per cent, so far as can be discerned. The important question thus at once arises, whether so large a contraction as this can be supposed to occur without the evolution of heat. It seems to me that this is quite improbable, although I have not been able, after some pains, to complete a direct test in answer to the inquiry. Under high pressure conditions such experiments are so difficult, however, that the failure to obtain direct results is not surprising: for in view of the necessarily small lateral dimensions of high pressure apparatus, and the relatively slow reaction, etc., the investigation of

the thermal data sought is almost bound to prove futile. There is so little opportunity favoring the accumulation of heat.

In nature, where a large extent of rock is liable to be placed under the influence of water at high temperatures, the conditions are much better adapted to promote solution. Let it be called to mind that the rate of reaction increases rapidly with increasing temperature, i. e., with increasing depth below the surface of the earth. Furthermore, that whatever heat is produced by the reaction itself, will in its turn additionally stimulate its intensity. Hence it is altogether probable that at sufficient depths within the earth, the heat evolved by the action of water on rock will be generated faster than it can be dissipated. The result would be a subterranean, local source of heat whose efficiency is variable with the character of the rock, the topography of the surface, the temperature and depth of the available mass of water, etc. If we endeavor to associate volcanic action with some such agency as here sketched, we should agree that the occurrence of volcanoes at the sea shores presents the case of greater probability, while inland volcanoes are not excluded. The probability would increase for those rarer cases in which the necessary quantity of water is in any accidental way liable to reach the quantity and special kind of rock in question. Even under suitable conditions of temperature therefore, and near the ocean, active volcanoes would be a rare occurrence, seeing that the particular ingredients needed for an intense reaction are not everywhere available. Nor is it necessary that the material ejected by the volcano be the identical rock acted on, since in the above experiments with retorts, dissociations are already in evidence. The material which ultimately remains hydrated will depend on other reactions and segregations, possible after termination of the hydration, or upon reactions within the hydrated magma.

Finally with the completed hydration of the given silicate in the manner evidenced by the above experiments with capillary tubes; in other words, after the available water or rock have been used up, the reaction would definitely subside and the volcano become extinct.

It is not necessary to trespass speculatively as far as I have done in the preceding paragraph to detect the definite bearing of the present results on the potential fluidity of magmas, their diminished density, etc. I will give a rough sketch of the geologic conditions involved to make my meaning clearer. *A* represents a vertical section of the ocean with the depths laid off in kilometers. As the water put into reaction must remain liquid at least up to 200° (say), the water available for the reaction must be tapped from a level deeper than 150 meters, or roughly

200 meters below the surface of the ocean. Otherwise the water would be vaporized and inactive. This depth is marked *dd* in the diagram to show its relation to the surrounding ocean and shore lines.

B, in the diagram, represents the adjoining land, with the isotherms higher than 200° located in place. The newest measurements put these about 400 kilometers apart per 100°

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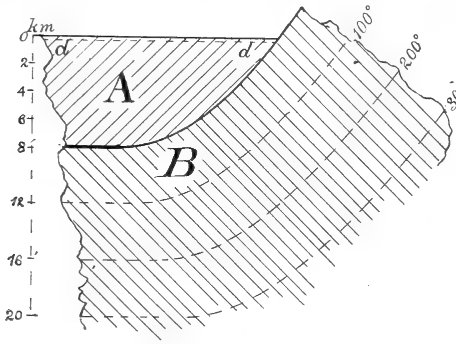


C. If therefore water from anywhere below the level *dd* enters the rock by whatever catastrophe, penetrating as far as the isotherm for 200°, the rock there, if of the character of the above experiments, will become liquified, apart from pressure. The hydrated silicate in place is thus virtually fluid below the contours of the isotherm 8 kilometers below the surface. Thus the depth of the isotherm of potential fusion is placed about five times as near the surface as would be the case for the corresponding igneous fusion. Estimating the pressure on the 210° isotherm as much below 3000 atmospheres, the whole phenomenon is in an interesting way placed within laboratory reach.

Brown University. Providence, R. I.

ART. XVI.—*Conrad's Types of Syrian Fossils;* by C. E. BEECHER.

IN the official report of the United States Expedition to the Dead Sea and the River Jordan, by Lieut. W. F. Lynch, U. S. N., published in 1852,* there is a chapter (pp. 209–229) by T. A. Conrad, containing a "Description of the Fossils of Syria collected in the Palestine Expedition," accompanied by an appendix (pp. 230–235) and illustrated by thirty lithographic plates.

It appears from the context that the collections studied by Conrad were from three separate sources: (1) Material obtained by Dr. H. J. Anderson, in charge of the geology of the Lynch expedition; (2) specimens furnished by the Friends of Missions, a society in Cincinnati, Ohio; and (3) specimens loaned by Professor Silliman from the Geological Cabinet of Yale College.

Professor R. P. Whitfield in a paper on Syrian fossils, published in 1891,† makes the following statement regarding these collections (l. c., p. 383, footnote): "I have made every reasonable effort to find the originals of Mr. T. A. Conrad's species described in the Official Rept. of the U. S. Exped. to the Dead Sea and River Jordan, under Lieut. W. F. Lynch, for the purpose of identification and comparison as well as verification; they seem, however, to have been entirely lost sight of, as inquiries of the different societies and persons having charge of collections, where they might have been deposited, have entirely failed to bring any of them to light."

It is, therefore, a matter of some scientific importance to be able to announce in this notice, that in the course of the unpacking, classification, and redistributing of the material belonging to the Geological Department of the Yale University Museum, now in progress, a box has been found containing a number of Conrad's types of Syrian fossils. The box label reads: "Fossils of Palestine described in Lt. Lynch's Report by Dr. Anderson, Sept. 1852." The specimen labels are written in Conrad's handwriting and have torn edges, a method of labelling quite characteristic of that author.

In order to define clearly the precise value of this material as a collection of types, the terminology proposed by Schuchert‡

* Official Report of the United States Expedition to explore the Dead Sea and the River Jordan. By Lieut. W. F. Lynch, U. S. N. 4to, pp. 236, plates 1–22 and 1–8 in Appendix. Baltimore, 1852.

† Observations on some Cretaceous Fossils from the Beyrût District of Syria, in the Collection of the American Museum of Natural History, with Descriptions of Some New Species. By R. P. Whitfield. Bulletin of the American Museum of Natural History, vol. iii, No. 2. 1891.

‡ What is a Type in Natural History? Science, N. S., vol. v, No. 121, 1897.

is followed, and a catalogue of the specimens is herewith appended.

Types of Syrian Fossils described by T. A. Conrad in Lt. Lynch's Expedition to the Dead Sea, 1852, in the collections of Yale University Museum.

Holotypes.

No. (Number in parenthesis = original number).

1	(22)	*Mactra pervetus* Conrad. (l. c.) Plate 8, fig. 49.	1 specimen.
2	(35)	*Holaster syriacus* Conrad. Plate 1, fig. 2.	1 specimen.
3	(71)	*Lucina syriaca* Conrad. Plate 10, fig. 57.	1 specimen.
4		*Nerinea syriaca* Conrad. Plate 12, fig. 72.	1 specimen.

Cotypes.

5	(10)	*Cardium biseriatum* Conrad.	1 specimen.
6		*Cardium biseriatum* Conrad. Plate 6, fig. 39.	1 specimen.
7	(16)	*Tellina syriaca* Conrad. (No. 16 figured.) Plate 10, fig. 61.	4 specimens.
8	(23)	*Tellina syriaca* Conrad. Plate 10, fig. 60.	1 specimen.
9		*Echinus syriacus* Conrad. Plate 1, fig. 1.	1 specimen.

Paratypes.

10	(1, 3)	*Chenopus syriacus* Conrad.	2 specimens.
11	(2, 4)	*Natica indurata ?* Conrad.	2 specimens.
12	(5, 6)	*Turritella magnicostata* Conrad.	6 specimens.
13	(17)	*Turritella magnicostata ?* Conrad (young).	1 specimen.
14	(8, 15)	*Cardium biseriatum* Conrad.	7 specimens.
15	(14)	*Trigonia syriaca* Conrad.	4 specimens.
16	(25)	*Chenopus turriculoides* Conrad.	12 specimens.
17	(36)	*Holaster syriacus* Conrad.	2 specimens.
18		*Ammonites syriacus* Conrad.	4 specimens.
19		*Cardium crebriechinatum* Conrad.	1 specimen.
20		*Inoceramus Lynchi* Conrad.	1 specimen.
21		*Isocardia crenulata* Conrad.	1 specimen.
22		*Mactra pervetus* Conrad.	2 specimens.
23		*Natica indurata* Conrad.	1 specimen.
24		*Natica syriaca* Conrad.	1 specimen.
25		*Cidaris spines.*	6 specimens.

Hypotypes.

26	(26)	*Ostrea scapha ?* Roemer (Conrad).	1 specimen.
27	(29)	*Exogyra Boussingaulti* D'Orbigny (Conrad).	8 specimens.
28		*Exogyra Boussingaulti* D'Orbigny (Conrad).	7 specimens.
29		*Ostrea virgata ?* Goldfuss (Conrad). Plate 1, figs. 7, 8.	1 specimen.
30		*Ostrea virgata* Goldfuss (Conrad).	3 specimens.
31		*Gryphæa vesicularis ?* Lamarck (Conrad).	1 specimen.

Total 22 species.

Species labelled by Conrad but not described.

No. (Number in parenthesis = original number).		
32 (12)	*Cucullæa indurata* Conrad.	2 specimens.
33	*Cucullæa indurata* Conrad.	1 specimen.
34	*Cucullæa syriaca* Conrad.	2 specimens.

The entire report contains figures and descriptions of one hundred species, and the present collection furnishes authentic examples of twenty-two of these, nine of them being represented by figured specimens.

The Syrian collection now in the Yale University Museum came chiefly through American missionaries, and comprises accessions made at various periods during the last seventy-seven years, beginning with 1821 down to 1898. The dates of the various lots, as far as can be determined from the labels and from references to the early volumes of this Journal,* where they are in part described, are as follows :

1821. Specimens sent by Rev. Eli Smith of the Class of 1821, Yale College.
1824 and 1827. Three boxes containing collections made by Rev. I. Bird, Class of 1816.
1840. Specimens from Rev. Hibbert.
——– Specimens from Rev. Dr. A. T. Pratt, Class of 1847.
1857. Collection sent by Rev. H. H. Jessup, Class of 1851.
1861. Specimens from Rev. Dr. Van Dyck.
1898. Specimens in collection of Professor O. C. Marsh.

Since Conrad's report was published in 1852, many of the specimens he described from the Yale Cabinet doubtless belonged to the earliest accessions. Thus, the first considerable description of Syrian fossils is based in part on one of the oldest collections in America and one of the first received from foreign lands.

Yale University Museum,
New Haven, Conn., Feb. 1st, 1900.

* This Journal, I, vol. ix, pp. 337–351. 1825. Description of Minerals from Palestine; by Professor [F.] Hall.
Ibid., vol. x, pp. 21–29. 1825.
Notice of Minerals, etc., from Palestine, Egypt, etc., in a letter from the Rev. Isaac Bird, Missionary, to the editor, dated Beyroot, Palestine, March 15, 1825, with remarks upon the specimens, by the editor. [B. Silliman.]
Ibid., vol. xii, pp. 145–147. 1827.
Notice of various facts relating to Palestine in a letter from the Rev. Isaac Bird to Prof. Hall.
Ibid., vol. xv, pp. 374–378. 1829.
Notices of Palestine, etc., in a letter from the Rev. I. Bird to the editor, dated Lazaretto Rooms, Malta, June 20, 1828, received Oct. 7.

ART. XVII.—*An Electrical Thermostat;* by WILLIAM DUANE and CHARLES A. LORY.

IN some research work that one of us has been carrying on recently, it became necessary to construct an easily adjustable thermostat that would keep the temperature of a bath constant to within $\frac{1}{1000}$th of a degree Centigrade for a considerable length of time. It was thought that this could be accomplished best by means of an electric current, because if the current passed through wires suspended in the bath, or through a conducting bath itself, heat would be supplied throughout the whole bath much more easily and quickly than by other means.

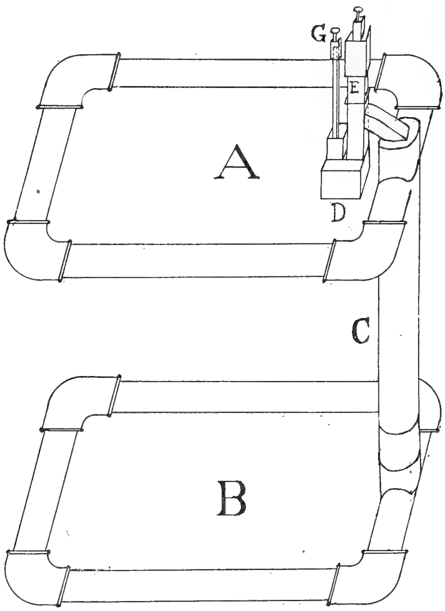
The result of our endeavor to construct such an electrical thermostat has been quite satisfactory. During the trial runs the temperature of the thermostat remained constant to within less than $\frac{1}{2000}$th of a degree Centigrade, although several times the temperature of the surrounding atmosphere varied 12° C. or 15° C. in half an hour.

The general scheme is this. Through a conducting liquid, or through wires immersed in one which is non-conducting, flows an electric current, that is sufficiently large to heat the liquid up to a temperature considerably above the constant temperature required. A system of tubes containing a liquid with a large temperature-coefficient of expansion is placed in the bath. By means of a suitable mechanism the expansion of this liquid interrupts or reduces the strength of the heating current when the required temperature has been reached. The temperature of the bath then begins to fall, whereupon the original current is started again automatically. It might seem at first thought, that, owing to the time required for the heat to penetrate through the walls of the tubes to the expanding liquid within, the making and breaking of the circuit would take place rather slowly, and the temperature of the bath would be oscillatory instead of constant. This is undoubtedly true to a certain extent. Practically, however, with our arrangement of apparatus the variation of temperature is too small to be detected even by a differential thermometer that would indicate a change of temperature of $\frac{1}{2000}$th of a degree Centigrade. Indeed the efficiency of the apparatus is due to the fact that the makes and breaks follow each other so rapidly, that there is not time for the temperature to change perceptibly between them. Often two, three or even more interruptions of the current occur in one second. At first we used an ordinary wash-boiler containing about 150 liters of water as a

bath. The boiler was placed in a large wooden box and packed in around the sides with wool. A light wooden frame immersed in the water served as a rack to hold the wires conveying the current. We encountered considerable difficulty, however, owing to the wires becoming very brittle and breaking after a few days' use. This was the case with wires of copper, iron and German silver. A direct current, too, seemed to produce a much greater effect than an alternating one of the same heating power.

To obviate this difficulty we constructed a wooden trough ($80^{cm} \times 40^{cm} \times 50^{cm}$) and filled it with a weak solution of common salt in water. The two ends of the trough were com-

1



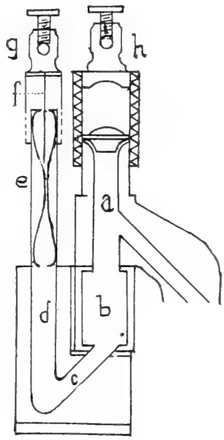
pletely covered inside with sheets of zinc, that served as electrodes by means of which an alternating current from the 110 volt electric light circuit passed through the solution. This method of heating proved very satisfactory.

The liquid in the bath was kept in continual and rapid circulation by means of four stirrers operated by a small water motor.

The tubes containing the expanding liquid were of thin brass about $2{\cdot}5^{cm}$ in diameter. They were fastened together by means of iron joints in the form of two rectangles (A and B, fig. 1). The tube C connected the two rectangles together.

The whole system of tubing was placed in the bath with the planes of the rectangles horizontal and the tube C vertical. The portion G D E is the regulating device. After the tubes had been filled through a small hole in the top of the tube E a brass cap was screwed on the end of E, pressing a small disk of lead tight down over the hole. This formed a perfectly air-tight stopper. The form of the stopper and regulating device finally adopted is shown in fig. 2. The portions of the tube marked *a c* and *d* were of iron; *b* was of brass, and *e* of glass. *a* and the whole system of tubes A, B and C were filled with alcohol, and *b*, *c*, *d* and *e* up to the platinum wire at *f* with pure mercury. The alcohol in the large system of tubes expanding and contracting forced the mercury up and down, making and breaking the contact at *f*. At the joints between *a* and *b*, *b* and *c*, and *d* and *e* were rubber washers; and screw clamps, not shown in the figure, pressed the several parts firmly together.

2



The reason for inserting the small brass reservoir *b* in the portion of the tube containing the mercury was this. Without it we found that the temperature at which contact was made and broken at *f* kept gradually rising, indicating a small leakage of alcohol. Since the insertion of an easily amalgamated metal in part of the tubing containing the mercury completely corrected this fault, we surmised that the leakage must have taken place along the contact surface between the mercury and the iron tubing. No appearance of alcohol at *f* was noticed, but it could easily have evaporated too rapidly.

The binding posts at *g* and *h* were connected to a circuit containing a dry cell and a relay. The relay opened and closed a second circuit containing an electromagnet, which in turn controlled the main heating circuit.

For temperatures only a few degrees above that of the room the makes and breaks at *f* may open and close the heating circuit completely; but for temperatures 30° or 40° C. above that of the room it is better to arrange the circuits so that the makes and breaks at *f* throw an extra resistance into and out of the main circuit. In this case, of course, the larger of the two main currents must be sufficient to heat the bath up to a higher temperature than the required one, and the smaller insufficient to maintain it at that temperature.

In our apparatus the glass tube *e* was open at the top. A large variation in the atmospheric pressure might produce a change in the temperature at which the makes and breaks take place on account of the slight compressibility of the alcohol. No such effect has been noticed, however. If it occurred the fault could easily be remedied by fastening a tube with a large bulb on its end to the tube *e*. The bulb, of course, would have to be below the surface of the bath, so that the temperature of the air within it would not change.

In practice it is easy to set the regulating device to working at any desired temperature between that of the room and one a few degrees below the boiling point of the liquid in the tubes, as follows. With the cap *h* unscrewed, allow the bath to heat up slowly, and when the desired temperature has nearly been reached, screw the cap down. A little practice will enable one to set the thermometer at a temperature within a small fraction of a degree of the desired one.

The reason that the interruptions of the current follow each other so rapidly is not quite clear to us. It may be due to a slight jarring of the surface of the mercury at *f*. In any case the best results are obtained with pure dry mercury, and when the platinum wire touches the convex surface of the mercury column near its center.

Hale Physical Laboratory, University of Colorado, U. S. A.

ART. XVIII.—*The Toxic Action of a Series of Acids and of their Sodium Salts on Lupinus Albus;* by RODNEY H. TRUE.

IN former papers (1 and 2*) dealing with the toxic action of dissolved salts and their electrolytic dissociation, Dr. Kahlenberg and I presented some evidence bearing on the effect of the ionization of the molecule on the poisonous properties exerted by these substances on the radicles of *Lupinus albus.*

In those papers the belief was expressed that the toxicity of acids was in very large part due to the action of the hydrogen ions formed in the aqueous solution. The question as to the toxicity of the anions and of the residual undissociated molecules, in case ionization was not complete, was raised and postponed for treatment in a further paper. Accordingly, in 1896, Dr. Kahlenberg and I began the study of the toxic action of the sodium salts of a series of acids for comparison with that of the acids themselves. Considerable time has elapsed since then, and now, with the consent of my colleague, I have put together the results of the study. Dr. Kahlenberg is, therefore, responsible for the chemical part of the experimental work; for the botanical part and for the formulation of the results embodied in this paper I, myself, am responsible.

Methods. — Since the method used has been elsewhere described (1) in detail, it will suffice to say here that radicles of *Lupinus albus* were exposed to the action of a series of concentrations of the aqueous solutions of the compounds involved, and the greatest concentration observed, in which the primary roots survived after an exposure of twenty-four hours.

The sodium salts were prepared by adding to solutions of the acids chemically equivalent quantities of sodium hydroxide (NaOH).

Discussion of Principles Involved.—It is a well established fact of chemistry that if, to a solution of an acid, an equivalent amount of a strong base like NaOH be added, a clean-cut reaction will take place, resulting in the substitution of the metal (Na in the compound cited) for the H of the acid, and the formation of water.

Since the physiological activity of $\overset{+}{H}$ has been shown to be very great (2 and 3) and that of $\overset{+}{Na}$ relatively very slight, (1) the effectiveness of the $\overset{+}{H}$ component may be roughly tested by comparing the toxic activity of the acid with that of its sodium salt, differences in the degree of ionization being borne in mind. As is well known, acids dissociate in varying degrees of completeness and the anions or acid radicles may be signifi-

* See Bibliography, p. 192.

cant also, likewise the residue of un-ionized molecules, should dissociation be incomplete. The same general considerations obtain also for the sodium salts. Since in both acid and salt the same anions are found, the difference between the death-limits of acid and salt measures roughly the action of $\overset{+}{H}$ ions, provided that ionization be found in like degree in both. Should it be unlike and incomplete, the toxic action will vary according to the number of molecules ionized (1).

Letting t equal the toxic value of any acid or salt, k the partial-toxicity of the cations, a the partial-toxicity of the anions and m the partial-toxicity of the residual undissociated molecules, then, should ionization be complete, $t=k+a$. Should ionization be incomplete, $t=k+a+m$. In the case of acids, k would represent the partial-toxicity due to $\overset{+}{H}$ ions; in the sodium salts it would represent the partial-toxicity of the $\overset{+}{Na}$ ions.

In hydrochloric acid we have a type of the stronger inorganic acids. It dissociates very freely in relatively strong concentrations and gives a valuable standard of comparison by which to judge the weaker organic acids. It is practically completely ionized at the death-limit characteristic for the white lupine, one molecular-weight in grams dissolved in 6400 liters, hence this case illustrates the simpler instance, $t=k+a$.

The toxic-value of the Na salt, NaCl, is one gram-molecule of the substance dissolved in sixteen liters of water, or briefly, 16. At this relatively great concentration, this salt is not completely dissociated, only about 85 per cent of the molecules being ionized (5). The value 16 represents, therefore, the sum of the partial-toxicities of $\overset{+}{Na}$ ions, $\overline{Cl}$ ions and 15 per cent of undissociated molecules. Here, $t=k+a+m$.

We may obtain an approximate idea of the actual value of $\overset{+}{H}$ ions by a comparison of the toxicity of HCl with that of NaCl. As appears from data just given, it seems to lie near 6400. Strong corroborative evidence may be obtained by a study of sulphuric acid and some of its compounds. This acid is practically entirely ionized (6) at the death-limit for lupines, 12,800, and since it splits off two $\overset{+}{H}$ ions from every molecule, it would have, in chemically equivalent quantities, twice the number of $\overset{+}{H}$ ions found in HCl, and should have its death-limit at one-half the concentration of the mono-basic acid. This has been realized by experiment (1). Should one of the H atoms of H_2SO_4 be replaced by some relatively harmless metal, the death-limit should lie at approximately the same

concentration as that of HCl, provided ionization were complete. These suppositions have been practically realized (1).

We are now able by means of these values to obtain an expression representing approximately the toxic-value of $\overset{+}{H}$ ions. If the molecule splitting off two $\overset{+}{H}$ ions when completely dissociated at the death-limit, gives a value of 12,800, and the same molecule in which one H is replaced by a metal gives one-half that value, plainly all other factors become practically zero in comparison with the H. This ion may, therefore, be given approximately the absolute value of 6400. We see that all other ions concerned are negligible in comparison with $\overset{+}{H}$ ions; hence $\overset{+}{K}$ ions and $\overline{SO_4}$ ions have a relatively insignificant value. If $\overset{+}{H}$ ions have a toxic-value of 6400, plainly in HCl with a toxic-value of 6400, the $\overline{Cl}$ ions are relatively insignificant (1). Results of experiments not yet in print have shown that for the lupines the toxic-values of NaCl and KCl are essentially alike, 16, hence $\overset{+}{Na}$ ions are likewise relatively insignificant.

The question now arises, what is the actual significance of the relatively weak factors, the anions and the undissociated molecules? Since the sum of the toxic-values of $\overset{+}{Na}$ ions, $\overline{Cl}$ ions and 15 per cent undissociated molecules equals 16, plainly no one factor can have a value exceeding 16. Probably any one of them is considerably less. For the present, however, it is sufficient to know that the toxic-value of $\overset{+}{Na}$ ions and the toxic-value of $\overline{Cl}$ ions is each less than 16, or less than $\frac{1}{400}$ that of $\overset{+}{H}$ ions.

In the discussion of the toxic-values of the compounds here concerned, I shall try to fix, as accurately as may be, the partial-toxicity due to each factor.

Discussion of Results.—In order to present in as clear a manner as possible the results of greatest significance in this discussion, I have omitted the details of the individual experiments, only indicating their outcome. In the tables, as well as in the discussion of data, the toxic-values are expressed by the numbers of liters of water in which the molecular-weight in grams, of the substances concerned, must be dissolved, to give the physiological results seen. The same numbers would occur as the denominators of the fractions indicating those parts of a gram-molecule which, dissolved in one liter of water each, would form the strongest concentrations in which the primary radicles of *Lupinus albus* could survive for twenty-four hours.

Since in experiments of this nature the fixing of limits can be only approximate, I do not wish to claim for the numerical results here given a strict mathematical accuracy. These values may be taken as an approach only to the exact relations existing.

In the following table, the data are arranged in six columns. Column 1 gives the names of the compounds discussed. Column 2 gives the death-limit of each substance for the lupines. Column 3 gives the partial-toxicity due to cations. Column 4 gives the partial-toxicity due to anions. Column 5 gives the partial-toxicity due to undissociated molecules *of the acids.* Column 6 gives the degree of ionization found or estimated to exist in the solutions at the concentrations indicated by their death-limits. Since the toxic-value of $\overset{+}{Na}$ ions has been found to lie at less than 16, when dissociation is complete, it is not indicated here in the column giving the toxic value of the cations. It lies always less than 16. The values of the undissociated molecules of the salts are not indicated, since the necessary data for their determination are not at hand. As is shown below, however, these values are usually very small. This may be in part due to their non-toxic nature, and in part to the small proportion of un-ionized molecules left in the solutions at the toxic-limits. It will be seen from the table that these sodium salts ionize very freely.

In ascertaining the data for column 6, I have made use of Ostwald's determinations for the acids. Since Ostwald's investigations (7) extended only to the dilution n-1024, a point lying, in all cases, short of the limits found for the plants, I have resorted to estimates based on the data given.* The degree of ionization of the salts was calculated from Kohlrausch and Holborn's excellent series of tables (4).

* To illustrate the method of calculation used, the following example is given. Ostwald, Zeitschr. f. physik. Chem., iii, p. 174.

Formic acid.

$\mu\infty = 375$

v	—	100m	Differences.	Ratio of increase.
8	15·22	4·05		
16	21·19	6·63	(2·58)	
32	29 31	7·79	(1·06)	
64	40·50	10·78	(2·99)	(1·33)
128	55·54	14·76	(3·98)	(1·3)
256	75·66	20·12	(5·36)	(1·3)
512	102·10	27·10	(6·98)	(1·3)
1024	104·70	35·80	(8·70)	(1·25)
2048		(46·67)	(10·87)	(1·25)
4096		(60·26)	(13·59)	(1·25)
6144		(68·15)	(8·15)	(1·20)

K = 0,0214

Interpolated numbers are in parentheses. Last three ratios assumed. Ionization at $v = 6400$ is taken to be roughly 70 per cent.

TABLE OF RESULTS.

Substances.	Death-limit.	Part-Tox. of cations.	Part.-Tox. of anions.	Part.-Tox. of un-ionized molecules.	Ionization at Death-limit. per cent.
Hydrochloric acid	6400	6400			100
NaCl*	16		16	16	85
Hydrobromic acid	6400				100
NaBr*	16				
Hydriodic acid*	6400				100
NaI*	24				
Nitric acid	6400				
Sulphuric acid	12800	12800			100
$KHSO_4$	6400	6400			100
Fatty series.					
Formic acid	6400	4480	36	1884	70
Na formate	50		36		90
Acetic acid	1600	960	11	629	15
Na acetate	25		11		85
Propionic acid	3200	1088	36	2076	17
Na propionate	50		36		88
Butyric acid	3200	1152	36	2012	18
Na butyrate	50		36		87
Aromatic series.					
Benzoic acid	6400	2432	185	3783	38
Na benzoate	200		185		92
Salicylic acid	6400	6016	85	300	94
Na salicylate	100		85		91
m. oxybenzoic acid	3200	2560	36 ?	600 ?	40
Na. m. oxybenzoate	50		36 ?		
p. oxybenzoic acid	3200	1600	36 ?	1564 ?	25
Na p. oxybenzoate	50		36 ?		
b. nitrobenzoic acid	6400	6400	9–36	00	100
Na o. nitrobenzoate	25–50		9–36		85
m. nitrobenzoic acid	12800	6400	6400	00	100
Na m. nitrobenzoate	400		385 ?		
p. nitrobenzoic acid	12800	6400	6400	00	100
Na p. nitrobenzoate	400		385 ?		
Protocatechuic acid	3200	1792	35 ?	1423 ?	28
Na protocatechuate	50		35 ?		
Gallic acid	6400	2240	85 ?	4075 ?	35
Na gallate	100		85 ?		
Cinnamic acid	12800	2880	785	9135	45
Na cinnamate	800		785		96
Hippuric acid	6400	1920	10 ?	4470 ?	30
Na hippurate	25		10 ?		
Carbolic acid	400	00	00	400	00
Na carbolate	400				

* Results worked out by Miss May Randall, 1899.

Inorganic Compounds.—In the inorganic acids one finds very free ionization, as a rule, so free that in HCl and other halogen acids, nitric acid and sulphuric acid, practically complete dissociation exists at their death-limits for lupines. Since the toxic-values of these acids are essentially alike, 6400 for each H atom of the molecule (1), it is clear that they possess in common a component of great intensity of action, so great as to render other factors negligible in comparison. This common constituent is the equivalent quantity of $\overset{+}{H}$ ions present. In view of this coincidence, one is safe in inferring that the death-limit for $\overset{+}{H}$ ions lies at about 6400 for the lupine.

The sodium salts of these acids, as far as tested, agree in having a low toxic-value; indeed, NaCl is as nearly harmless to lupines as any salt yet tested, having its death-limit at 16. Since at this concentration about 85 per cent of the molecules are ionized, 16 represents the sum of the toxic activities of $\overset{+}{Na}$ ions and $\overline{Cl}$ ions from 85 per cent of the molecules and 15 per cent of residual molecules. If separated into their respective partial-toxicities, one would expect comparatively slight values for each component.

Organic Compounds.—As a rule the organic compounds offer somewhat greater difficulties than the inorganic substances. In general, ionization of the molecule is seldom complete at the death-limit, the sodium salts usually ionizing more freely than the corresponding acids. Consequently it is rare that the effect due to $\overset{+}{H}$ ions is relatively as great as in HCl, and the partial-toxicity due to the anions and undissociated molecules becomes much more important. In some cases it may even exceed that of the $\overset{+}{H}$ ions.

Fatty Series.—In the examples from the fatty series examined, one finds considerable diversity in the results obtained. Formic acid is distinctly the most toxic member of the group and undergoes likewise a distinctly greater degree of ionization,—70 per cent as against from 15 per cent to 18 per cent in the other acids. The result is a distinct prominence relatively and absolutely of the $\overset{+}{H}$ component and a correspondingly reduced effect due to anions and undissociated molecules.

The sodium salts show no similar differences in their action, the formate, propionate and butyrate giving identical death-limits. The acetate is as weak in its poisonous action as any organic Na salt examined. These salts all undergo roughly the same degree of ionization, but from 10 per cent to 15 per cent of residual molecules existing in the solutions at the death-

limits. This fact, while not giving a numerically accurate ground for argument, permits us, nevertheless, to arrive at a rough idea of the relative effectiveness of ions and undissociated molecules. To illustrate, formic acid owes to the action of the anions of 70 per cent of its molecules plus 30 per cent of un-ionized molecules remaining, 30 per cent of its toxic-value, 1920 units. Sodium formate has a toxic-value of about 50. It has been shown above that the partial-toxicity characteristic for 100 per cent of $\overset{+}{Na}$ ions is less than 16; here, therefore, the partial-toxicity due to $\overset{+}{Na}$ ions cannot be more than 14 and is doubtless less. This leaves about 36 units due to anions derived from the ionization of 90 per cent of the molecules plus that due to the residual 10 per cent of molecules not thus ionized. Plainly the toxic-value of either of these factors cannot exceed the sum 36. One may roughly say that the toxic-value of these anions derived from 90 per cent of the molecules is less than 36. Since in the acid 70 per cent of the same anions are formed, in a more dilute solution the action of the anions must be still less. One may, however, safely express it still as less than 36. Comparing this value with the sum of the values of anions plus undissociated molecules, the action of the anions is seen to sink into insignificance, and the toxic-value due to the sum is practically due to 30 per cent of undissociated molecules.

In acetic acid, but 15 per cent of the molecules are ionized at a concentration of one gram-molecule in 1600 liters; nevertheless, 60 per cent of the toxicity of the acid is due to $\overset{+}{H}$ ions derived from this proportion of molecules; 85 per cent of undissociated molecules plus 15 per cent of anions are responsible for 640 units or 40 per cent of the toxicity of the acid. A calculation similar to the above based on the action of the sodium salt shows that in this acid, again, the anions can play no measurable part, the undissociated molecules, of which 85 per cent are present, being responsible for practically 40 per cent of the toxic action of the acid.

In the remaining members of the fatty series studied, the relative importance of the action of the residual molecules increases; in both propionic and butyric acids the undissociated molecules comprise about 80 per cent of the total number, and exert about 65 per cent of the toxic action of these acids.

Aromatic Series.—The study of the aromatic compounds has been very seriously limited by lack of data from the physico-chemical side. This is especially true of the sodium compounds, a large number of which seem not to have received study along the line of their electrolytic dissociation. In but

few cases, therefore, can the line of argument pursued above receive thoroughly satisfactory application to these acids. The toxic-values of the acids and salts have, however, been tabulated, as well as estimated values for the factors, judged from the physiological evidence.

In general, the acids show a very considerable variation in their toxic-values due to their chemical structure. The boundary-concentrations lie between 3200 and 12,800. Dissociation varies between rather wide limits, from 24 per cent in p. oxybenzoic acid to 100 per cent in o. nitrobenzoic acid. The toxic activity here as in the fatty series is preponderant in the cations when dissociation is far advanced. When this is not the case, the influence of the residual molecules exceeds it more or less decidedly. In hippuric, salicylic and o. nitrobenzoic acids, the $\overset{+}{H}$ ions are especially influential. In benzoic and cinnamic acids, the action of the residual molecules is distinctly predominant. In general, the sodium salts show here a very much weaker toxicity than the acids, the death-limit varying between 25 and 100. In Na cinnamate the limit lies at 800 and gives the most vicious sodium salt in the entire list. As far as the available data go, the salts of these acids dissociate freely, from 85 per cent to 96 per cent at the death-limit.

In the case of acids, the dissociation of whose sodium salts has been determined, relations not unlike those obtaining in the fatty series, already discussed, are found to exist.

In the case of benzoic acid, dissociating about 38 per cent at the death-limit, 38 per cent of the toxic effect may be regarded as due to $\overset{+}{H}$ ions, 62 per cent to residual molecules and to anions. The toxic-value of the sodium salt is 200; less than 15 units can be referred to $\overset{+}{Na}$ ions, 185 units are chargeable to 92 per cent of anions and 8 per cent of residual molecules. Since we may safely place the toxic-value of this number of anions at less than 185 units, the toxic-value of 72 per cent of undissociated molecules is more than 3783.

In the m. and p. nitrobenzoic acids it becomes difficult to apply the line of reasoning thus far used to the explanation of the results. The possibility exists, of course, that the death-limits are not correctly located. The thought also suggests itself that at this great dilution hydrolytic changes may take place affecting the essential structure and physiological properties of the molecule. Owing to this anomalous behavior, a further study of these isomers seems especially advisable.

Cinnamic acid deserves a passing comment. Although a mono-basic acid, it has an extremely toxic effect, equalling that of H_2SO_4, which cuts off two H ions per molecule at the death-

limit. This unusual viciousness is plainly to be charged in large part to the undissociated molecules, but the anions here seem to be much more significant than in any acid before mentioned. Probably about 785 units are chargeable to the anions, about 15 units to $\overset{+}{Na}$ ions, about 2880 units to $\overset{+}{H}$ ions and about 9135 units to the residual molecules.

For comparison with the above organic acids, in which the acid H is in the carboxyl form (COOH), carbolic acid and its Na compound have been added. Here the H is in the hydroxyl form (OH). The toxic-value of carbolic acid is 400 (8), about $\frac{1}{16}$th that of the completely ionized mono-basic acid. A study of the electrical conductivity has shown (9) that ionization is practically absent here, and the undissociated molecules form, of course, the only factor. No diminution of the toxic-value would be expected, therefore, in the Na compound. As a matter of fact (8), the toxic limit of the Na compound is likewise 400. This is a situation fairly typical for the phenols.

Summary.—In closing, the main points brought out in the course of the above discussion may be summarized as follows:

Given the degree of ionization of the molecules of an acid and of its Na salt at the limit-concentrations, it is possible approximately to analyze the resultant toxic effect into those component parts which are due (1) to the $\overset{+}{H}$ ions, (2) to the anions and, in case ionization is incomplete, (3) to the residual undissociated molecules.

In the inorganic acids cited, complete ionization exists at the limit-concentration, e.g., in HCl, HBr, HNO_3 and others. The anions are probably toxic, but in a very slight degree when compared with $\overset{+}{H}$. Consequently, in these acids the purest $\overset{+}{H}$ effect is seen and the minimum effect from other constituents. $\overset{+}{Na}$ ions are but slightly toxic.

In both the fatty and the aromatic series of organic acids, the acids dissociate much less freely as a rule and exert their toxic action usually through three factors: $\overset{+}{H}$ ions, anions and residual undissociated molecules. In case dissociation is well nigh complete, the partial-toxicity of $\overset{+}{H}$ ions usually exceeds that of other factors. In case ionization takes place less freely, the undissociated molecule plays an important part, often exceeding that played by $\overset{+}{H}$ ions. In general, such residual molecules possess a great degree of toxicity. In cinnamic acid over 77 per cent of the total toxic action is due to undissociated molecules.

In general, the anions of organic acids possess relatively slight toxic properties, oftentimes well nigh so slight as to be neglected, as in acetic and hippuric acids. In benzoic acid, and especially in cinnamic acid, the anions are distinctly toxic but to a degree relatively slight when compared with the action of $\overset{+}{H}$ ions or of the undissociated molecules.

Since $\overset{+}{Na}$ ions are but weakly toxic and the anions are oftentimes relatively ineffective, it follows as a rule that $\overset{+}{Na}$ salts have in general from but $\frac{1}{2}$ per cent to 3 per cent of the toxic-value of the corresponding acids.

Carboxyl hydrogen, as seen in the above organic acids, is many times more toxic than hydroxyl hydrogen, as seen in carbolic acid. Since practically no $\overset{+}{H}$ ions are formed in the phenol, the Na compound gives no marked change of the toxic-limit.

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Art. XIX.—*Explorations of the "Albatross" in the Pacific;* by Alexander Agassiz.

III.

[*Letter No. 3*, dated Suva Harbor, Fiji Islands, December 11th, 1899, to Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries, Washington, D. C., by Alexander Agassiz.]

We left Papeete, November 15th, after coaling and refitting on our return from the Paumotus. During our trip to Suva we made a few soundings from Tahiti to Tonga, striking the northern extension of the deep basin lying to the eastward of Niue; the depths ranged from 2472 to 2882, the bottom being red clay. This would indicate a greater extension westward of the zone over which the manganese-nodule bottom is known to extend.

After leaving Niue we steamed for the deep hole of the Tonga-Kermadec Deep, about 75 miles to the eastward of Tonga-Tabu, and in 4173 fathoms made a haul with the Blake beam-trawl, by far the deepest trawl haul yet made. The gear was carefully inspected, and strengthened as far as practicable by Captain Moser, and it was with considerable anxiety that we laid out 5000 fathoms of wire rope for our haul. Fortunately, everything went off successfully, and we landed the trawl safely back on deck. To my great surprise we found in the bag a number of large fragments of a silicious sponge belonging probably to the genus Crateromorpha, which had been obtained by the Challenger in the Western Pacific, but in depths less than 500 fathoms. We also brought up quite a large sample of the bottom; it consisted of light brown volcanic mud mixed with radiolarians.

We decided to trawl at 4173 fathoms rather than wait for a possibly deeper sounding, as the conditions for work were admirable and we did not care to run any risk from a change of weather. After our haul we made a still deeper sounding in the proximity of the 4762-fathom sounding marked on the chart, and found 4540 fathoms, with the bottom of the same character as at the place where we trawled. We also took a couple of soundings in the line from Vavau to the southern extremity of the Lau Group in Fiji, but found, as we expected from the soundings given farther south, comparatively shoal water, viz: 1381 fathoms. In the channel north of Yangasá, where we cross the Lau Plateau, between Yangasá and Mothe, we found 453 fathoms, with bottom composed of coral sand, pteropod ooze, and a few globigerinæ. Between Namuka and Yangasá we obtained 324 fathoms; between Namuka and

Marambo, 600 fathoms; between it and Kambara, 450 fathoms; and finally, about 15 miles west of Kambara, we sounded in 990 fathoms. These soundings would indicate a continuous plateau of moderate depths from Wailangolala south upon which the islands of the Lau Group rise.

On our way back to Papeete from the Paumotus we examined the eastern coast of Tahiti, and from Papeete examined the western coast as far as Port Phaeton, at Tararoa Isthmus. We examined, in a general way, the Leeward Society Islands: Murea, Huaheine, Raiatea, Tahaa, Bora-Bora, Motu Iti, and Maupiti. There are excellent charts of the Society Islands, so that it was comparatively simple to examine the typical points of the group and to gain an idea of their structure as far as it relates to coral reefs. The Society Islands are all volcanic islands edged with shore platforms, some of great width, upon which the barrier or the fringing reefs of the islands have grown. The structure of the reefs of the Society Islands is very similar to that of the Fiji reefs round volcanic islands. A comparison, for instance, of the charts of Kandavu, Viti Levu, Mbengha, Nairai, and of other volcanic islands in the Fijis, with those of the Society Group, will at once show their identity. Huge platforms of submarine denudation and erosion characterize both, with fringing and barrier reefs determined by local conditions. Perhaps it is easier to follow the changes which have taken place in the Society Islands; and such islands as Tahaa and Bora-Bora, where we anchored, as well as Maupiti, are admirable examples and epitomes of the structure and mode of formation of the coral reefs of that group.

In Motu Iti and Tetuora the volcanic peaks have disappeared leaving nothing but a shallow platform, upon the outer edges of which sandy coral islets have been thrown up. There is, however, one point in which the barrier reefs of the Society Islands differ from those of Fiji. The barrier reefs in Fiji are generally indicated merely by reef flats, upon which the sea breaks, and an occasional rocky islet or negro-head; only rarely do we find sand keys upon the fringing reefs of the islands of Fiji. In the Society Islands, on the contrary, we find the line of the barrier reef usually well indicated by long lines of narrow islets thrown upon the reef platforms, exactly as they are in the Paumotus. These islands and islets are usually well wooded, and thus give a very peculiar aspect to the barrier reef. In the case of Bora-Bora, Maupiti, and Aitutaki, for instance, we have a central volcanic peak of considerable height surrounded by a wide lagoon, the sea edge of which is formed by a fringe of wooded islets and islands forming a more than half-closed ring around the central island, which, in

Bora-Bora and Maupiti, rise in slopes and nearly vertical walls, the former to a height of nearly 2400 feet, the other to about 1100 feet.

The only island of the Cook Group which we examined was Aitutaki, as Atiu is composed of elevated limestone, and Rarotonga is volcanic; I hoped we might find that atoll to be in part volcanic and in part composed of elevated coralliferous limestone; we found it to be volcanic, an island with the structure of Bora-Bora on a smaller scale.

We anchored at Niue, an island composed of elevated coralliferous limestone showing three well-marked terraces, the lowest of not more than 5 to 10 feet and in many places disappearing completely, the limestone cliffs rising vertically from the sea well into the second or even the third terraces. The vertical faces of the cliffs are dotted with caverns and deeply indented by small cañons extending at right angles to the face of the shore or forming blunt headlands separating short reaches of coral sand beaches.

The second terrace varies in height from 50 to 60 feet, the third from 90 to 100 feet. The second terrace is deeply undercut; and in the higher vertical cliffs extending into the third terrace from the sea, the former positions of the terraces are usually indicated by lines of caverns. There are corals on the sea slopes of the first terrace, extending to 10 or 12 fathoms, growing much as they are found at Makatea.

From Niue we went to the Tongas, which we found a most interesting group. The elevated Tertiary coralliferous limestones take here their greatest development, and are on a scale far beyond that of their development in the Lau Group of the Fijis, or the Paumotus. The first island of the Tongas we visited, Eua, is perhaps the most interesting of the islands, composed of Tertiary elevated coralliferous limestone I have visited. From Dana's account of it, evidently given at second hand, I expected to find an island somewhat like Viti Levu on a very much smaller scale. But as we steamed up to it from the east there could be no mistaking the magnificent face of nearly vertical limestone cliffs forming the whole eastern face of the island, and at points rising to over a thousand feet in height. At all projecting points lines of terraces were plainly marked: at the northern point three could be followed, and at the southern extremity five, with traces of a sixth perhaps.

Upon rounding the southern extremity of the island we could see that the island was composed of two ridges, running north, separated by a deep valley, the western ridge being much lower than the eastern, not rising to a greater height than a little over 500 feet. The western ridge is also composed of limestone, and at the headlands we could trace three ter-

races. There is a narrow shore platform along the western face, at many points of which there are blow-holes where the sea throws up spray to a considerable height, but these blow-holes are best seen off Cook Point, the southern extremity of Tonga-Tabu.

As we steamed along the western face of Eua Island we could see the ridges of the eastern side rising above the crest of the lower ridge, its slopes indicating a valley of considerable size. We anchored at English Roads, opposite the outlet of the drainage of the interior basin, where a small river has cut its way through a depression in the shore terrace. On landing we followed the crest of the western ridge for a few miles and could see the whole valley forming the basin of the island lying between the two ridges, at our feet; the slopes leading to the bottom are quite gentle, and the valley dips very gradually northward back of the outlet on the western shore. Nothing could show more clearly that such an island was not an elevated atoll, but a plateau which has been eroded and denuded for a long period of time by atmospheric and other agencies, and in which a deep basin-shaped valley with gentle slopes has been gouged out—a plateau similar to that of Tonga-Tabu Island and of Vavau, but of greater height and less extent.

To the westward of the Tonga Islands is a line of volcanic islands extending nearly 200 miles, from Honga Hapai to Fanualai, some of which have been active very recently. Falcon Island disappeared in 1898, and Lette is still active. This line of volcanoes runs at a distance of from 15 to 20 miles parallel with the trend of the four irregularly-shaped plateaux upon which rise the Tonga Islands. They are the summits of a great ridge, over 200 miles in length, sloping very gradually to the westward and being somewhat more steep to the eastward, into deep water, towards the smaller platforms from which rise the volcanic peaks of the group. The plateaux of Tonga-Tabu, N muka, Haapai, and Vavau, are separated by deep valleys connecting the eastern and western flanks of the ridge. These four plateaux rise abruptly from the 100-fathom line. The extremity of the southern one is occupied by Tonga-Tabu Island. The land behind the cliffs of its southern coast rises to a height of over 250 feet, and slopes northward very gradually to form the low land which occupies the northern coast of the island, and is, except at Mount Zion and Cook Hill, not more than from 10 to 20 feet above the level of the sea. At Cook Point and along the southern coast three terraces are indicated. The northern coast is deeply indented by shallow bays, full of islands, reef flats, and reef patches, on which corals grow in great profusion.

In a distance of nearly 10 miles northward of Nuku-Alofa the plateau is nowhere more than 15 fathoms deep; and a long tongue runs northward, gradually deepening into 20 to 50 fathoms to the 100 fathom line.

The Tonga-Tabu plateau is separated from the Namuka Group plateau by a funnel-shaped channel with a depth passing rapidly into 300 fathoms from the 100-fathom line. The Namuka plateau is rectangular. The principal island is Namuka, where we anchored. We found the island to be composed of Tertiary elevated coralliferous limestone, with a shallow sink, filled with brackish water, occupying the southeastern part of the island. The sink is separated by a high sand beach, about 200 yards wide, from the sea.

Namuka Iki, the island next to Namuka, we found to consist, at its southern extremity, of stratified volcanic material, resembling somewhat the so-called soapstone of Fiji. I was told that other islands in this group, near Tonumeia, in the center of the Namuka plateau, were volcanic. Mango, as we could see it from our anchorage, appeared to be volcanic. So that this part of the Tongas is, like the Lau Group in Fiji, made up of islands in part volcanic and in part composed of elevated coralliferous limestone. The eastern edge of the Namuka plateau (which we did not visit) is edged with small low islands. We merely steamed by the western islands of the Haapai Group, but close enough to see that Tongua, Kotu, and Fotuhaa, which are respectively 120, 120, and 200 feet high, are composed of elevated limestone. The eastern flank of the Haapai plateau is edged with long, low islands, with extensive coral reefs along the reef flats of these islands.

The Haapai plateau is triangular, with isolated islands rising on the northwestern side from the deep water separating it from the Vavau plateau. It is separated from the Namuka plateau by a narrow channel with over 300 fathoms of water.

The northernmost plateau of the broad ridge of the Tonga Islands is the Vavau plateau. This is elliptical, with a long tongue extending on the eastern face of the ridge toward the northern point of the Haapai plateau, ending in isolated banks (the Disney and Falcon banks), lying to the northward of the broad channel, with over 400 fathoms separating it from the Haapai Group. The Vavau Group is by far the most picturesque of the Tonga Islands. It consists of the principal island of Vavau, extending across the northern part of the Vavau plateau. Several parts of the island of Vavau, as at the entrance to the harbor of Neiafu, and at Neiafu, are finely terraced; four terraces are indicated there, and other flat-topped smaller islands show traces of two or three terraces. The northern edge of Vavau Island rises to a height of more than

500 feet, and slopes in a general way southward and inland. The southern shore is deeply indented by bays and sounds, and flanked by innumerable islands and islets, some of considerable height (150 to 250 feet) which gradually become smaller and smaller as they rise toward the southward and eastward, these islands having been formed from the denudation and erosion of the greater Vavau. They form tongues of land and sea and sounds of all shapes and sizes, showing the traces of the former land connections of the islands and islets, and their disintegration on the eastward and southward by the action of the sea. The islands and islets to the southward of the main island rise from more or less extensive reef flats which stud the whole plateau, and on which corals grow in great profusion (mainly Millepora, Porites, Pavonia, Pocillopora, Fungia, and Astrea), to a depth of 5 to 6 fathoms in the sounds. In the Namuka Group they extended in the more open waters to 14 and 16 fathoms.

It is evident that in the Tonga Group, which is a very extensive area of elevation, the recent corals have played no part in the formation of the masses of land and of the plateau of the Tonga Ridge, and that here again, as in the Society Islands and the Cook Islands, both also in areas of elevation, they are a mere thin living shell or crust growing at their characteristic depths upon platforms which in the one case are volcanic, in the other calcareous, the formation of which has been independent of their growth.

We expect to leave for the Ellice, Gilbert, and Marshall Islands as soon as we can coal and refit.

ART. XX.—*On Ægirite Granite from Miask, Ural Mts.*; by L. V. PIRSSON.

SOME little time since, there was received in this laboratory a small suite of rock specimens from Krantz in Bonn representing the mica-nephelite syenite from Miask in the Urals, long known as "miascite" from the locality. On account of a pressure of work in other directions, the sections from these rocks have been only recently examined for classification and arrangement. It was at once seen that one of them is an ægirite alkali granite, a rare and interesting type of rock.

Most of the specimens agree well with the descriptions of the common types of this locality given by several authorities.* They are light gray to white rocks spotted with glittering black plates of biotite often collected in stringy layers so that the rock has a pronounced gneissoid character. Under the microscope the sections show a dark mica, probably biotite, alkali feldspars of various kinds, albite, microcline, microperthite, cryptoperthite, etc., with nephelite, sodalite and cancrinite. They frequently indicate that the gneissoid structure is secondarily induced by dynamic pressures from the undulatory extinctions and broken character of the minerals.

The specimen which is the occasion of this note is a light colored rock of much the texture and feeling of a rather firm sandstone of medium grain; it has a distinctly saccharoidal character. It does not possess the glittering black mica of the other types but is spotted with small grains of a dull black ferro-magnesian mineral; these, a millimeter or less in diameter, are not regularly sprinkled through the rock, but are gathered in clusters or small areas, where they are closely crowded, while the intervening spaces are quite devoid of them and show only the light feldspathic grains. The actual amount of this, the only dark component, is small compared with the quartz and feldspar, and the rock is therefore distinctly leucocratic in character.

In thin section the minerals observed are apatite, zircon, ægirite, albite, microcline, orthoclase and quartz. The apatite is comparatively rare in small stout prisms; the zircon is in minute well crystallized prisms and larger anhedra; it is more abundant than apatite.

Albite is rather abundant and well twinned according to the albite law, not according to the carlsbad. It is recognized by its optical relations and measurements and by Becke's method on contacts with quartz.

Microcline is seen in small fragments and in places the unstriated alkali feldspar has transitions through areas of undu-

* Rose, Reise nach dem Ural, vol. ii. p. 42, 1842; Mouchketov: Rosenbusch, Mass. Gest., 3d Aufl., p. 178, 1896; Zirkel, Lehrb. d. Petr., 1894, p. 415; Karpinsky, Guide VII Intern. Cong., No. V (Versant orientale de l'Oural, 1897, p. 21).

latory or rolling extinction into those of undoubted microcline twinning. The inference is not far that this twinning has been produced by pressure, and the microcline is therefore not an original constituent but a paramorphic one.

The ægirite has the usual properties of this mineral and is present in distinct but not well crystallized grains.

The quartz is recognized by its being a mineral of low refraction and birefringence, colorless, without cleavage and of positive uniaxial character. It occurs in two ways, in the formless irregular areas between other more automorphic constituents common to granitic rocks, and in clear round grains embedded in the feldspars and appearing like the corrosion quartz of the French petrographers. Everywhere the quartz shows optical strains and broken undulatory extinctions, indicative of its having been subjected to severe pressure; its total amount in the rock is considerable.

The structure indicates also that the rock has been under dynamic pressure in that the constituents appear broken, angular and with at times a distinct approach to the "mortar" structure. Aside from this the structure is nearest that of an aplitic granite.

Classification.—From what has been said it is clear that the rock is an ægirite granite or taking into account its sugar granular structure and relative paucity of dark minerals, perhaps better an ægirite aplite. Its alkaline character points clearly to its being a differentiation product of acid oxyphyric, leucocratic character of the alkaline magmas at Miask, and it would seem probable that it is from a dike possibly of some size which has suffered from orogenetic movements.

In the literature of the Miask area accessible* to the writer there is no mention of this type, and as it is a very interesting and important one in several ways, the author has thought well to call attention to it, and also with the hope that more may be learned of its geologic and genetic relations.

Quartzose igneous rocks containing ægirite are known but are still rare. They are known chiefly in the finer-grained and porphyritic textures such as the grorudites of the Christiania region, the Bearpaw Mts., Montana and in the rockallite of Rockall Island, and the granite porphyry of the Judith Mts. In alkaline granites the iron-bearing component is usually a hornblende, such as riebeckite and ægirite I have been able to find mentioned but once in the literature by Bröggerf† in a granite near Drammen in South Norway.

* Rose, Reise nach dem Ural, 1842, vol. ii; Guide des Excur., VII, Cong. Geol. Inter., No. V, Karpinsky. Karpinsky mentions two or three others in Russian journals.

† Spaltenverwerfungen Langesund-Skien, Nyt. Mag. for Naturvid, vol. xxviii, p. 40.

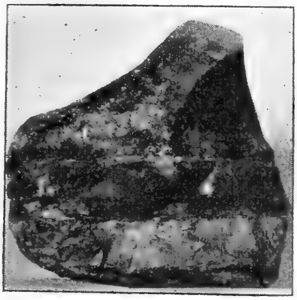
Sheffield Laboratory of Mineralogy and Petrography,
Yale University, New Haven, January, 1900.

ART. XXI.—*Illinois Gulch Meteorite;* by H. L. PRESTON.

[Read before the Rochester Academy of Science, Jan. 23d]

THE Illinois Gulch siderite was found in Illinois Gulch, Deer Lodge County, Montana, in 1899, on the bed rock about four feet below the surface, by J. Parle while placer mining.

The mass was somewhat ham-shaped, as will be seen by the following cut.



Illinois Gulch Meteorite.*

Its dimensions are $63 \times 104 \times 105^{mm}$ in its greatest diameters. There are two rather large typical pittings, one on either side, with numerous quite small ones and three sharp angular ridges on the upper or necked surface. But little genuine crust is left, the bright silvery metallic iron being visible in small patches through the oxidized surface, over a portion of the mass.

On certain portions of the mass, particularly in the deeper pittings, there is quite a thick deposit of carbonate of lime, showing that it had lain for a long time in the position where found.

In slicing the mass into five sections, the protosulphide of iron, troilite, was found only on one section, and on this in very small quantities; the largest nodule being only 6^{mm} in diameter, with numerous small fissures, from 1 to 5^{mm} in length, extending in various directions from it, that are filled with the same material.

This nodule occurred in the lower center of the section. At the extreme right, within 5^{mm} of the edge of the section, occurred another patch of small fissures, covering an area of about 8^{mm} in diameter, filled with troilite.

* The horizontal lines on cut are due to the fact that the photograph was taken after the mass had been cut.

On etching the iron, no distinct figures of any character were brought out, but a surface of a dark gray groundmass was left filled with bright silvery-white flakes, without any definite form, or sharp line of contact, between them and the dark grey groundmass.

Over the surface are scattered in single crystals, occasionally in groups, a very dark steel gray crystallization, from ½ to 1^{mm} in length and $\frac{1}{2}^{mm}$ or less in width, that are probably the phosphide of iron and nickel, rhabdite.

The character of the etched surface of this iron is more nearly, lacking the supposed rhabdite crystals, like the Morrodal Norway siderite, than any other with which I am acquainted.

This mass is in the possession of Ward's Natural Science Establishment, and when received by them weighed 2,435 grams, but at that time a fragment weighing possibly fifteen grams had been chiseled off the end of the narrow neck.

An analysis of this siderite by Mariner and Hoskins, of Chicago, gave

Fe	92·51
Ni	6·70
Co	·16
Si	trace
P	·62
C	·01
	100·00

Specific gravity 7·7.

This meteorite will be designated the "Illinois Gulch" meteorite, Deer Lodge County, Montana.

ART. XXII.—*The Silurian-Devonian boundary in North America. I. The Chapman Sandstone fauna;* by HENRY S. WILLIAMS.

THE identification of the Chapman sandstone fauna of Aroostook County, Maine, with the typical Ludlow "Tilestone" fauna of Murchison, furnishes important new evidence bearing upon the question of the exact boundary between the Silurian and Devonian systems in North America. Before the identity was recognized by the author, the general position of the fauna, in relation to the change in sedimentation from limestone to the sandstones of the Gaspé peninsula, was seen to give probability of the presence of an uppermost Silurian fauna in this part of the continent. A discussion of this subject was arranged to take place at the summer meeting of the Geological Society in 1899, when Mr. Schuchert proposed to present arguments for inclusion of Lower Helderberg faunas in the Devonian. The absence of Mr. Schuchert led to the postponement of the discussion to the winter meeting in December, 1899. At that meeting, I briefly referred to the facts here given, but did not discuss the paleontological evidence upon which the identification was based. In the present article it is proposed to state briefly the paleontological reasons for believing the Chapman sandstone fauna to be the American equivalent of the "Tilestone" fauna of Wales, leaving the full description and illustration of the fauna for a future work.

The accurate determination of boundary planes between geological systems on different continents is of greater importance than local geologists are wont to appreciate. As in the case of current money, the crucial test of a geological classification is most deeply felt when attempt is made to pass it in a foreign country. All the geological system boundary-planes were first determined outside America; and, following the rule of historical precedent, such standard planes must form the basis of comparison for all local standards set up in America. For our own uses alone it is not important that our systems should accurately correspond at their limits with the same systems of Britain and Europe. They differ more or less in their fossil contents; and a general agreement in boundaries, adjusting them to the peculiarities of our formations, is sufficient for the mapping and discussion of our local geological problems.

When, however, the history of organisms is under discussion, it becomes essential to correlate with accuracy the chief time boundaries for all continents; and for this purpose a few

datum planes must be established, whose exact correlation, with the standard section in the country where the time boundary in each case was first defined, is known with precision. Such boundaries, it is granted, were purely arbitrary in the first place; but once established they become, like Greenwich or the Christian era, standards for all future scientific uses.

The fact is well known to paleontologists that the faunas of formations of the same geological age often differ widely in their species in separate regions of the same continent. And the faunas now living on the west and east coasts of America, under like conditions of temperature and environmental conditions, contain very few identical species. Even in the same sea (as the fauna off Florida and that off New England), modern faunas differ as greatly as two contiguous faunas of the geological column. These facts make it essential for the student of evolution to distinguish between modifications of a fauna which are (*a*) coördinate with the change of place (geographical distribution), and those (*b*) coördinate with passage of time (geological range). It is for such reasons that I have been led to consider the determination of geological boundaries as worthy of exhaustive and painstaking investigation.

Such methods of precision were applied in the determination of the American equivalent of the Cuboides zone.* And, as a secondary result of that study the origin of the Neodevonian faunas of New York State was traced to a northwestern source, while the Mesodevonian faunas were found to be more closely related to southern faunas (recognized in Brazil, South America) and not identical with the common Mesodevonian fauna of Europe.

Although a well-marked biological boundary between the Devonian and Carboniferous of North America is found, where *Spirifer disjunctus* is replaced by *Spirifer marionensis*, and *Syringothyris* first appears, the corresponding boundary in standard European sections is so indistinct that I do not have confidence that this boundary as drawn in America will agree precisely with the European standard.

The discussion of the Hercynian problem has resulted in the placing, by several of the best continental European paleontologists, of the Silurian-Devonian boundary below the Hercynian fauna. Kayser,† followed by others, has adopted the opinion that the American equivalent of the Hercynian fauna is to be found in the Lower Helderberg.

* The Cuboides Zone and its Fauna: a discussion of Methods of Correlation. Bull. Geol. Soc. Amer., vol. x, pp. 481–501, pl. xi–xiii, 1890.

† Die Fauna der ältesten Devon-Ablagerungen der Harzes. Abhand. geol. special Karte, Preussen, etc. Band ii, heft 4, pp. 284–285, 1878.

Dr. J. B. Clark and Mr. Schuchert* have attempted to prove, on paleontological grounds, that the Lower Helderberg fauna has a Devonian "aspect," and, trusting to their theories, have proposed to classify the formations containing the typical Lower Helderberg faunas in the Devonian system.†

When Professor Kayser's paper first appeared I was struck with the force of his paleontological argument for classifying the Lower Helderberg and Hercynian faunas together; but I was not then satisfied with the proof of the Devonian age of all the faunas so classified. When Dr. Barrois' paper, on the Erbray faunas appeared,‡ it was gratifying to find confirmation of this opinion.

Dr. Freck's papers§ were also emphatic in claiming a Devonian age for the Hercynian, and the combined evidence of these gentlemen (and others taking part in the discussion), pointed very strongly to the conclusion that we must drop our Silurian-Devonian boundary below the main part of the Lower Helderberg, if we would adopt European (continental) usage.

The similarity of the Gaspé section to the typical Welsh sections of the Silurian system, running up to the base of the Old Red sandstone, gave me hopes that a study of the sections in northern Maine might reveal some faunas representing the upper part of the Silurian more closely than do the faunas of New York. As the fossils of Maine were studied, a transition fauna was found which throws considerable light upon the exact position of the boundary plane between the two systems, Silurian and Devonian, in our North American rocks.

The fauna referred to was first discovered by Olof O. Nylander, in the town of Chapman, Aroostook County, Maine, in a sandstone, called Chapman sandstone, in a report on the geology of Maine recently made to the U. S. Geological Survey [which will appear as Bulletin No. 165]. The fauna is being described and figured, but a preliminary examination of it has revealed its close correlation with the Ludlow Tilestone fauna of Murchison, and still more closely with the Upper Arisaig fauna, D of Honeyman's section, which was "unhesitatingly referred to the Ludlow Tilestone" by Salter, in 1862.‖

This Chapman sandstone fauna is the latest marine paleozoic fauna so far recognized in Maine, unless the Moose River fauna with Oriskany species be a little later. It is contained

* The nomenclature of the New York series of Geological formations, Science, N. S., vol. x, pp. 874–878, Dec. 15, 1899.

† See paper read at the Geol. Soc America, Washington, December, 1899.

‡ Fauna du Calcaire D'Erbray, by Charles Barrois, Mem. de la Soc. géologique du Nord, tome iii, April, 1889.

§ Ueber das rheinische Unterdevon und die Stellung des "Hercyn," by Fritz Freck: Zeitschr. d. Deutsch. geolog. Gesellschaft; Jahrg. 1889, pp. 175–287, etc.

‖ Quart. Jour. Geol. Soc., xx, p. 334, 1864.

in a massive brown sandstone and argillaceous layers stratified therewith. Its comparison with other faunas links it with the so-called Oriskany of the Moose River region further west, and also with the early beds of the Gaspé sandstone further east. For this general region it is a representative of the transition zone from calcareous formations, which are unmistakably Lower Helderberg in age, up to coarse gray and red sandstones containing Devonian plants, reported to be seven thousand feet thick on the Gaspé peninsula and to represent the Old Red sandstone phase of the Devonian system.

The fauna contains some twenty-five or thirty good species, a few of which can be identified with species of the Tilestone and Upper Arisaig faunas already described. A few Gaspé species described by Billings are closely approached; but, as a fauna, the resemblance to the typical Tilestone species of Murchison's Silurian system is most striking and suggestive.

The faunas, as reported in my preliminary list, are as follows, viz:

Fauna of 1099 A, south branch of Presque Isle stream in Chapman township, Aroostook Co., Me.

Rensselæria (Beachia) n. sp., cf. B. suessana.
Holopea cf. Danai.
Loxonema cf. planogyrata.
Pleurodictyum sp.
Spirifer gaspensis.
Orthonota n. sp. (cf. undulata).
Palæoneilo cf. constricta.
P. cf. plana.
P. cf. maxima.
P. 5 or 6 new species.
Sanguinolites n. sp. (cf. clavulus).
Leiopteria, six species.
Pterinea rectangularis (cf. flabellum).
P. (three species).
Cf. Glyptodesma sp.
Cypricardella cf. gregarius.
Nucula (n. sp.).
Beyrichia tuberculata Klöden.
Psilophyton princeps.
Stem large plant.

The second fauna, 1099 C, is from Edmund's Hill, in the northern part of the same township:

Rensselæria (Beachia) n. sp. cf. suessana.
Spirifer arrectus, cf. "cyctopterus" Billings.
S. cf. concinnus.
Homalonotus cf. Vanuxemi.

Chonetes Nova-Scotica Hall (cf. sarcinulatus var. plana Schnur).
Chonetes canadensis Bill (cf. Leptæna lata Sow.).
Bellerophon, two species.
Holopea sp.
Several gastropods.
Avicula cf. textilis.
Lamellibranchs, several genera and species.
Orthoceras, a fragment.
Tentaculites.
Beyrichia tuberculata Klöden.
Plant fragments.

Loose specimens, picked up in various places in the county, have furnished in addition to the above :

Sp. raricostus Bill.
Avicula cf. securiformis.

The significance of the correlation of this Chapman sandstone with the Tilestone of Murchison, is found in the fact that *the Tilestone contains the topmost fauna of the original Silurian system of Murchison.* This fauna was described by Sowerby in the "Silurian System" (1839), and afterwards the Tilestone was placed by Murchison himself in the Silurian ("Siluria," 1854). This change was brought about by the recognition, by Murchison, that paleontological evidence is of greater importance in the determination of the age of rocks than petrographical evidence. By the study of "Silurian System," it is perfectly evident that the Silurian system was intended by Murchison to include all the fossiliferous formations lying below the Old Red sandstone. We find this indicated clearly on pages 3 and 4, and still more clearly expressed on page 7 of the Introduction of "The Silurian System," where are found the following words (referring to the name Silurian): "The term was no sooner proposed than sanctioned by geologists, both at home and abroad, as involving no theory, and as simply expressing the fact, that in the 'Silurian region' *a complete succession of fossiliferous strata is interpolated between the Old Red Sandstone and the oldest slaty rocks.*" We find that the reason for including the Tilestones in the Old Red was the fact that the soil weathered out reddish in the same way as the Old Red sandstone did where it was typically represented. These Tilestones, however, were not always red in themselves; but, on passing below, the typical Upper Ludlow weathered gray. This seems to have been the prime reason in the mind of Murchison for classing the Tilestones with the Old Red. When, however, the first edition of "Siluria" was written, the fact that the species of this fauna

were marine and not freshwater types, and that some of them were identical with species in the formation below (which he called Silurian), led Murchison to call this Tilestone the top member of the Silurian instead of the bottom of the Old Red. In "Siluria" appears a concise description of the transition from the Ludlow rocks into the Old Red sandstone, as seen in Carmarthenshire and Pembrokeshire: "In all these places, strata of dull greenish-gray argillaceous sandstone, minutely micaceous, differing chiefly from the type of the Ludlow of Shropshire in being harder and thicker bedded, and which repose on rocks with Upper Silurian fossils, plunge under red and green strata (the red rab of Pembroke), or bottom beds of the Old Red sandstone" (p. 141).

The typical localities, from which the Tilestone fossils came, are Felindre on the Teme and Horeb Chapel, in the valley of Cwm Dwr, between Trecastle and Llandovery near Cwn Dwr. In the "Silurian System," the passage beds near Felindre are described as "hard, greenish, and reddish, highly micaceous sandstone, which contain the *Leptaena lata* and the *Terebratula nucula* of the Ludlow rock, together with casts of several shells, identical with those found in the tilestones of the Cwm Dwr, Caermarthenshire, and which have never been found in the Silurian System below its junction with the Old Red Sandstone" (p. 191).

The reason for placing the base of the Old Red sandstone above these tilestones is stated in the following passage in the "Siluria": "Even then, however, the fossils which were figured as characteristic of such tilestones exhibited little else, as I showed, than species common to the Ludlow rock itself. This zoological fact, and subsequent researches in other parts of England, above all those of Professor Sedgwick in Westmoreland, where the Upper Ludlow strata are much developed, have, for eleven years, led me to classify these tilestones with the Silurian rocks, of which they form the natural summit. For, even in their range from Shropshire through Hereford and Radnorshire, into Brecon and Carmarthenshire, whether they are of red or yellow colors, they are charged with *Orthoceras bullatum*, *Chonetes* (*Leptæna*) *lata*, *Spirifer elevatus*, *Orthis lunata*, *Rhynconella nucula*, *Cucullella ovata*, *Bellerophon trilobatus*, *B. expansus*, *Trochus helicites*, *Holopella* (*Turritella*) *obsoleta*, and the minute bivalved crustacean, *Beyrichia tuberculata*. All of these are the most common fossils of the Upper Ludlow rock; although a few of them descend as low as the Caradoc sandstone" (p. 139).

From these quotations it is evident that the Tilestone was regarded by Murchison as the upper member of the Silurian

system, as he defined it in 1854 and as it occurred in his typical sections.

My attention was first attracted to the possible equivalency of the Chapman sandstone and Tilestone of Murchison, (= Downton sandstone and Ledbury shale), by noting that *Leptæna lata*, of the list in the "Silurian System" is a true Chonetes, and closely resembles some of the specimens from Chapman. On studying up the definitions and synonymy of the species, it became evident that Davidson, who identified *Leptæna lata* von Buch with *Chonetes striatella* Dalman, in doing so, was following DeKoninck. In quoting synonymy, however, he excludes Sowerby's fig. 13, of plate 5, which, as figured, presents the flatness characteristic of the species occurring in the Chapman sandstone.

The Chonetes (No. M 248), of the Chapman sandstone, agree with Hall's *C. nova scotica** in size and form, and from descriptions, I judge that the small specimens referred to *C. canadensis* by Billings,† having the proportions of *C. melonica* are identical with Hall's species *C. nova scotica.* There is also a specimen (No. M250) (I originally referred it to Orthothetes, the hinge and beak being absent) which upon examination I find presents the typical characters of *Chonetes Canadensis* Bill. so far as they are visible. Dawson states that "the new species *Chonetes nova-scotica* is very characteristic of the upper member" [of the Arisaig section].‡ Hall compared the species with "*C. cornuta* of the Clinton group of New York,"§ but the Clinton species is much smaller than even the smallest specimens in the Chapman sandstone. Billings, in describing the Chonetes of the Gaspé series, calls his more gibbous form *Chonetes melonica;* and he compares this with *C. striatella* of Dalman, but finds it distinct (p. 16). *Chonetes canadensis* Billings, differs from the description of *C. melonica* in being nearly flat. Billings remarks, however, "*Small specimens of this species* [C. canadensis] *have nearly the proportion of C. melonica, but are always nearly flat, while those of the latter are always more convex*" (p. 18).† From a study of the descriptions, it is evident that these "small specimens," referred by Billings to his species *C. canadensis*, are identical with the form described by Hall as *C. nova-scotica*—thus linking together the Chonetes of the transition beds of the Gaspé section, formation D of the Upper Arisaig of Nova Scotia, and the Chapman sandstone.

Although I find no description of the specimens referred by Sowerby to the species *Leptæna lata* von Buch, the figure so

* Canadian Nat. and Geol., v, 144, fig. 2.
† Palaeozoic Fossils, vol. ii, pt. i, p. 18.
‡ Can. Nat. and Geol., v, 137.
§ Can. Nat. and Geol., v, 145.

labelled on plate 5 certainly appears as if nearly flat. Even were this not the case (which an examination of the type specimens would demonstrate), the fact that we have in the Gaspé series both fully gibbous and flat forms, which closely resemble each other in other respects, gives reason for supposing that the British form is at least represented by these Gaspé and Maine species.

In Hall's description of the Arisaig specimens of *Chonetes nova-scotica*, it is stated, "A stronger and more elevated stria often marks the median line from beak to base of the ventral valve."* This feature is seen on several of the specimens of the Chapman sandstone, and, curiously, it is not always the central plication. In one case several plications, a little out of the center, are thus enlarged. Such a trick of variation would seem, distinctly, to indicate close phylogenetic relationship.

In the Oriskany of Albany and Schoharie Counties, in New York, a form (*C. complanatus*) quite as large as Billings' *C. canadensis*, is described by Hall. The larger forms are all from the Gaspé, Maine and Oriskany faunas at the summit of the Silurian. *Leptæna lata*, which is figured as larger than the ordinary types of Chonetes, is said to be "*one of the most characteristic shells of the Upper Ludlow*" (Sil. Syst., p. 603).

The *Bellerophons* furnish a second set of diagnostic species. In the original list of the Tilestone fauna, four species of Bellerophon are named, viz:

Bellerophon carinatus.
B. striatus.
B. trilobatus.
B. globatus.

Bellerophon trilobatus is said to be a characteristic form of the Tilestone (Sil. Syst., p. 141). This species is represented in both the Chapman sandstone and formation D of Arisaig. In "Siluria," it is stated that *B. expansus*, "*B. Murchisonæ*, *B. carinatus*, and *B. trilobatus*, generally of small size, are most abundant everywhere in the upper beds of the Ludlow rock" (p. 231). *Bellerophon carinatus* and *B. trilobatus* are both represented in the Chapman; and Honeyman reports all four species from the Upper Arisaig, Zone D (Q. J. G. S., vol. xx, p. 343).

A third diagnostic form is called "*Agnostus tuberculatus* (*Battus tuberculatus* Klöden)" by Sowerby in 1839 (Silurian System, p. 604, plate 3, fig. 17). This is *Beyrichia tuberculata* Klöden. Several specimens of this species, or a very closely related form, are recognized in the Chapman fauna. Hall

* Descriptions of New Species of Fossils from the Silurian Rocks of Nova Scotia, by James Hall. Can. Nat. and Geol., vol. v, p. 145.

described, under the name *Beyrichia pustulosa*, a species from the Zone D of Arisaig, of which he says, "This species resembles very nearly the *B. tuberculata* of Klöden, as described and figured by Mr. T. Rupert Jones."* Of this form, Murchison writes, in "Siluria," as follows, viz: "Of the latter genus, the Upper Silurian species is *B. tuberculata.* It is very abundant from the Wenlock shale to the highest Ludlow stratum, and is a good index of Upper Silurian rocks, though found sometimes in the upper division of the Caradoc" (p. 236).

In addition to these characteristic species of the Tilestone fauna in the Maine and Arisaig rocks, a majority of the forms described in Sowerby's original list of that fauna are represented by the same, or closely allied forms, in both the Chapman sandstone and Zone D (Honeyman), Arisaig; as will appear from the following table, viz:

List of representative species of the Tilestone fauna in the Chapman sandstone, Maine; and Zone D, Arisaig, Nova Scotia.

Tilestone.	*Chapman sandstone.*	*Zone D, Arisaig.*
1. Cypricardia cymbæformis	Goniophora cf. Hamiltoniæ	C. cymbæformis, cf. Nuculites (Orthonota) carinata Hall
2. Pullastra lævis	Cypricardella cf. gregarius	not reported
3. Cucullæa antiqua 4. C. ovata 5. C. cawdori	Palæoneilo cf. cuneatus P. cf. concentricus P. cf. elongatus P. cf. nuculiformis P. cf. subovatus and others.	Cleidophorus cuneatus C. concentricus C. erectus C. elongatus C. semiradiatus C. nuculiformis C. subovatus
6. Arca —— ?	?	?
7. Avicula rectangularis	Pterinea rectangularis	? cf. Avicula Honeymani
8. Leptæna lata	Chonetes nova scotica C. canadensis	C. nova-scotica H. C. tenuistriata
9. Spirifer ptychodes (= S. elevata Dalman)	Sp. arrectus var. Sp. concinnus Sp. cyclopterus Bill. Sp. raricosta Bill.	Sp. regæcosta Sp. subsulcatus
10. Orthis lunata	?	?
11. Terebratula nucula (= Rhynchonella)	not seen	Rhynchonella (3 species)
12. Lingula cornea	not seen	Lingula sp.
13. Natica glaucinoides	?	?
14. Trochus helicites	Pleurotomaria sp. (M 227)	?
15. Turbo Williamsi	Holopea cf. Danai	?
16. Turritella obsoleta	?	Murchisonia Arisaigensis
17. T. gregaria	Loxonema cf. planogyrata	?
18. T. conica	?	M. aciculata

* See Jones' identification of this species in the Arisaig rocks in Q. J. G. S., xxvi, p. 492.

Tilestone.	*Chapman sandstone.*	*Zone D, Arisaig.*
19. Orthoceras semipartitum	A single fragment	O. punctostriatum
20. O. ?		O. nummulara Sow.
21. O. striatum		O. ibex Sow.
22. O. tracheale		O. exornatum
23. Bellerophon carinatus	B. carinatus	B. carinatus
24. B. striatus	?	B. striatus
25. B. trilobatus	B. trilobatus	B. trilobatus
26. B. globatus	?	B. globatus
27. Tentaculites scalaris ?	B. cf. elongatus	T. distans.
28. Battus tuberculatus	Beyrichia tuberculata	B. pustulosa Hall; B. equilatera

In addition to the above, *Homalonotus Knightii* König is reported from the Upper Ludlow, and also from Zone D, Arisaig; and an undetermined representative of the same genus appears among the Chapman specimens.

The presence of plants is further significant. In the Chapman sandstone a specimen of *Psilophyton*, which is probably *P. princeps*, appears in the midst of the marine fossils, giving evidence of proximity of land, and also of the transition condition leading up to the Old Red sandstone type of Devonian. "*Psilophyton* (?)" is also reported from the Upper Arisaig,* and it is the "Tilestone" of Wales (= Upper Ludlow and Downton sandstone), in which the earliest known traces of land plants appear in the Welsh succession.†

The above evidence leads directly to the conclusion that the fauna of the Chapman sandstone of Maine is the equivalent of the Tilestone fauna of Wales and of the uppermost Arisaig fauna of Nova Scotia. The latter has already been authentically identified with the "Ludlow Tilestone" by Salter, and the general fauna of the Upper Arisaig has been identified with the Lower Helderberg by all those who have studied the species.

The Nictaux iron-ore fossils indicate a somewhat younger fauna, which has been recognized by Dawson and other paleontologists as approximately equivalent to the Oriskany sandstone of the New York section.

In the Gaspé series the place of transition from the Gaspé limestones to the sandstones is very near to the horizon of the Oriskany sandstone further west. The stratigraphic and petrographic evidence in the Maine series points to the equivalency of the Chapman sandstone with the base of the Gaspé sandstone. The particular fauna of the Chapman sandstone is not known, at present, in the Gaspé series. But if this correlation with the Gaspé series be correct, the relations of the several known faunas of the Maine

* Ami. Catalogue of Silurian Fossils from Arisaig, Nova Scotia, Nova Scotia Inst. Sci., Ser. 2, vol. i, p. 185 (1892).

† H. B. Woodward, The Geology of England and Wales, pp. 104, 105 (1887).

series are in complete harmony with the known succession of the Gaspé faunas, and with such an interpretation. In that case, the Square Lake fauna of Maine would be equivalent to the fauna of the upper limestones in the Gaspé limestone series, and thus correspond with the known sequence of faunas in the Arisaig series.

Reviewing the whole evidence, the Chapman fauna must be regarded as the equivalent of the topmost fauna of the typical Welch Silurian system (= Upper Ludlow, Tilestone of Murchison, or Downton, and Ledbury formations of later authors). This places the Silurian–Devonian boundary for North America at the place where it was determined to be by deVerneuil in 1847,* classifying the Lower Helderberg formation in the Silurian system. The special Chapman fauna, I am at present inclined to think, is equivalent to the Lower Oriskany fauna, as recognized at Becrafts, and farther south in Virginia and Tennessee; but, however the precise correlation with the faunas of interior America may be settled, the place of the Chapman fauna above the general Lower Helderberg fauna is well established by the Gaspé and Arisaig sections.

New Haven, Conn., December, 1899.

* Note sur le parallélisme des Dépots Paléozoïques de l'Amérique septentrionale avec ceux de l'Europe. Bull. Soc. Géol. de France, 2d ser , t. iv.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Observations from the Astrophysical Observatory connected with the Smithsonian Institution at Washington;* by C. G. Abbot, Aid in charge.*

(1) *On the dispersion of rock salt.*—This subject has been investigated by several observers, first by Langley at Allegheny about 1886, and since then by Julius, Paschen, Rubens and Snow, and others. The object of making a further study of it was to very materially increase the accuracy of determination in the infra-red portion of the spectrum, with the hope of establishing the wave-lengths of the infra-red solar absorption lines discovered at this Observatory to a degree of accuracy corresponding with the accuracy of our knowledge of their minimum deviations in the spectrum of our great salt prism. There appeared to be strong grounds for hope of succeeding in this endeavor, in the consideration of the extraordinary facilities of the Observatory for such a research. Accordingly, the apparatus was made ready in July and August of 1898, and was actually tried in the latter part of August. Active work was, however, deferred until the latter part of December, and was done chiefly in January and February of 1899. While the method and results will be fully described in the forthcoming publication, a brief statement will be appropriate here.

The radiations of the sun were used as the source of energy up to a wave-length of 4μ, but from this point to 6.5μ (where the research was stopped, partly because the grating used was no longer applicable, and partly because further progress was of no particular interest) the radiations of an iron-gauze mantle heated in a Kitson lamp (burning vaporized petroleum) were employed. The radiations, from whichever source, fell first upon a slit 10 centimeters high, then upon a concave diffraction grating, and then upon the slit of the spectro-bolometer, which remained practically as used in taking solar bolographs. The grating apparatus being mounted according to Rowland's well-known device, radiations whose wave-lengths were multiples of each other fell upon the slit of the spectro-bolometer, and passed through to have their prismatic deviations determined. For instance, if the apparatus was adjusted so that the well-marked line of wave-length 0.5616μ in the fourth-order spectrum was found by visual observation falling at the center of the slit, then it would be certain that the radiations of the following multiples of this wave-length also fell there: 4/3, 4/2, and 4/1. The two latter would be well within the infra-red.

Suppose, now, the driving clock of the spectro-bolographic apparatus to be started, and a curve automatically produced just

*From the Report of Professor S. P. Langley, mentioned on p. 233.

as a bolograph would be. The form of this curve would be a straight line only broken by the minute accidential deflection of the galvanometer, except where the narrow bands of radiation at the above wave-lengths caused narrow, steep-sided elevations. If we suppose, still further, that either before or after this curve was made the direct sunlight was reflected upon the slit of the spectro-bolometer for several minutes, then a well-known portion of the solar spectrum energy curve would appear in its proper relative position on the same plate, and the positions of all the sharp elevations corresponding to known wave-lengths could readily be measured on the comparator with reference to determined solar absorption lines of the short bolographs. Thus the wave-lengths at as many points as desired could be determined without any circle readings whatever.

Practically, this process (somewhat altered in details) was gone through with for 38 positions between wave-lengths 0.76μ and 6.5μ; and not only once, but several times, with all the care for accuracy which could be taken. As a result, it may be said that the wave-lengths of the absorption lines in the infra-red solar spectrum discovered at this observatory can be told with an accuracy of about 3 parts in 10,000, while previous to this determination 1 part in 100 would have been all that could be claimed.

(2) *Distribution of energy from terrestrial sources.*—A number of energy curves were taken, in which the Kitson lamp, provided with mantles of various kinds, was the source. Among the mantles tried were the ordinary Welsbach (which consists of impure thorium oxide) and others composed of pure thorium oxide, iron oxide, uranium oxide, etc. The distribution of energy between different wave-lengths with these sources so different in illuminating power, is much less diversified than would be supposed, and goes strongly to show the wastefulness even of the Welsbach light as a source of illumination. For the invisible infra-red in all cases includes by far the major portion of the energy, and not the visible spectrum, as is the case with the sun and still more with phosphorescent substances. However, by the employment of a second spectroscope, or "sifting train," to exclude the stray infra-red radiations, we were able to determine the distribution of the relatively small amount of energy in the visible spectra of the various sources, and to show how far the ordinary Welsbach mantle outstripped them all for light, especially in the red, orange, and yellow. In these experiments a very considerable number (at least fifty) of absorption bands were discovered at wave-lengths beyond 4μ, which were most probably due to the gases given off by the lamp in burning, and perhaps solely to carbon dioxide.

(3) *Absorption in the solar spectrum.*—All the bolographic records, extending back to 1893, were carefully examined with regard to the changes in absorption noted in last year's report, and such changes were found to be more extensive and frequent

than had been supposed. The great decreases in absorption at Ψ and Ω were found to occur every spring, and to a lesser extent every fall; but were occasionally found in the winter also, but never in the summer. Such changes were found sometimes to go through their whole cycle in a week, and the absorption here is found to largely increase with declining sun.

The effect of water to absorb in this region was studied. Narrow cells of glass, whose absorption was known, were filled with water and placed in the path of the beam in taking bolographs of the solar spectrum. It was thus shown that "liquid" water absorbs most strongly at the particular regions where these annual variations are noticed. A fraction of a millimeter thickness of water was found enough to produce a great effect beyond the wave-length 1.2μ, and 2 millimeters thickness produced almost complete absorption of the solar rays beyond 1.2μ.

(4) *Constants of prisms.*—In the course of the reduction of measures on bolographs the exact index of refraction at the A line for the salt and fluorite prisms was required. Several measurements of these quantities made at different times failing of satisfactory agreement, several interesting things came out in finding the sources of error.

Rock salt prisms have not constant angles. It was shown that with a rising temperature the faces of the prism, if at first flat, became convex, and all three angles of the prism increase, unless they be determined at the centers of the faces. After the discovery of the very appreciable value of this change with our great prisms, it was at once found that their faces, when polished flat, are considerably concave after coming to their constant temperature. This is because of the surface heating caused by the friction of the polisher. It is now the practice to leave the faces polished very slightly convex, to allow for this temperature change.

Effect of this on the accuracy of bolographs and on the determination of prism angles. — After a very considerable amount of analytical investigation it was shown that such concavity of prism faces as was present when the bolographs were taken need introduce no error of appreciable magnitude in the relative deviations of the bolographs, provided the angle of the prism was determined to within 10 seconds of arc at a point a little nearer the back of the prism than the center of the faces, and this was done in practice. However, in determining absolute quantities like the index of refraction at A, it was found necessary to be far more particular.

(5) *Measurement of refractive indices at A.*—Diaphragms just wide enough for visual resolution of A were placed symmetrically on the faces, and the prism was so placed on the prism table that exactly the same beam of light entered the diaphragm in one position of the prism as in the other, in measuring both the angle and the minimum deviation. In this way very excellent

accord was obtained between several series of measures, and the following constants were fixed for the refractive indices of rock salt and fluorite in air at 20° C. and 760 mm. pressure. Average wave-length of radiations, 0.7604μ.

For rock salt $n = 1.536818 \pm .000009$
For fluorite $n = 1.431020 \pm .000006$

(6) *Do all rock-salt prisms have the same dispersion?* We were led to believe the affirmative upon this very important question by recorded results from many prisms, but we have conclusive evidence in the following comparison of the dispersion of three salt prisms, two from Russian and one from Bavarian salt, between wave-lengths 0.4μ and 4.0μ. The results indicated the affirmative, for the differences in the refractive indices in all this range never exceeded the probable experimental error of determination. To be more precise, the results at A were as follows:

Prism R. B. I. $n = 1.536818 \pm .000009$
Prism R. B. II. $n = 1.536844 \pm .000006$
Prism S. P. L. T. $n = 1.536812 \pm .000005$

At other points the differences were of the same order of magnitude.

It follows then, as has been anticipated and elsewhere pointed out by Langley, that this most interesting crystal, whose optical application from the time of Melloni to the commencement of these observations has been chiefly qualitative as a transmitter of special radiations, can now be used quantitatively with practical convenience in the form of a 60° prism, as a standard of refraction to which all wave-lengths may be referred with the same order of precision as to the grating.

(7) *The temperature-coefficient of refractive indices for rock-salt prisms.*—Bolographs were taken at low and high constant temperatures, and from these in connection with former results the temperature coefficient for the whole range of radiations covered by our bolographs was accurately determined.

(8) *Comparison of the efficiency of the bolometer and thermopile.*—It will be recalled that the thermopile has recently been made far more delicate and efficient by improvements of Rubens, so that with him and with some others it has displaced the bolometer for radiation work. A comparison made here between one of these instruments and our bolometer, No. 20, shows the latter, though of only one-fifteenth the surface, to give twice the deflection at the galvanometer when substituted for the thermopile. The galvanometer was besides more free from "drift" and "wiggle" with the bolometer, and there was no "creep" to the deflection with it, while such "creep" lasted 5 or 10 seconds with the thermopile. The bolometer has besides the advantage that it can be made more strictly linear and far narrower than

the thermopile, and is capable of exact setting in the spectrum. To offset these advantages, the thermopile requires no battery or balancing coils, and costs but about one-thirtieth as much as the bolometer with its necessary accessories. Nevertheless, to make it equal to the bolometer as regards "wiggle" and "drift" and capacity for accurate setting, it would require a mounting at least a fourth as costly as the bolometer and its accessories. On the whole the bolometer has the advantage, except in cost.

2. *The Electro-Chemical Equivalents of Copper and Silver*;* by THEODORE W. RICHARDS, E. COLLINS and G. W. HEIMROD.—Since Faraday pointed out in 1833 that the amounts of different substances, separated in successive cells by a given current of electricity, are proportional to the chemical equivalents of the several substances, numerous attempts have been made to verify this important law with rigid accuracy. None of these attempts have been very successful, since there are so many possibilities of error, owing to "side reactions," in the determination both of the electrochemical and the strictly chemical equivalents. The two metals most convenient for the practical application of this principle are copper and silver, and it seemed likely that a careful comparative study of the copper and silver "voltameters" might therefore be both of practical and of theoretical interest. Accordingly the present investigation, which has extended over a space of four years, was undertaken to clear up, if possible, the discrepancies.

It was found, in verification of the work of Foester and Seidel, that copper dissolves in cupric sulphate with the formation of a small quantity of cuprous sulphate, which attains a definite concentration for each temperature. Unless acid is present, cuprous oxide or hydroxide is formed by hydrolysis from this sulphate. The consequence of this singular condition of equilibrium is that from the pure acidified cupric solution less copper is deposited than corresponds with the current of electricity used, because some of the copper goes into the formation of cuprous sulphate: and from the partly cuprous solutions more copper is deposited than corresponds with the current, because in this case only single charges of electricity are set free from some of the ions deposited. We are thus between Scylla and Charybdis.

Moreover, before the cupric solution is made so dilute that its solvent action becomes negligible with a given current density, the deposition of hydrogen interferes with the exact determination of the electrochemical equivalent, even before the hydrogen is actually evolved in bubbles. Hence the use of a small cathode is dangerous beyond a limit which depends upon the degree of accuracy required. With small current density an approximate correction may be made for the area of the cathode. Vanni's

* This Abstract was prepared for this Journal by one of the authors. The original paper was presented to the National Academy of Sciences in November; it is printed in full in vol. xxxv of the Proceedings of the American Academy, and in vol. xxxii of the Zeitschrift für physikalische Chemie.

method of correcting the irregularity by adjusting the amount of acid present is simply a device for replacing the copper by cuprous oxide; and although its results are not very erroneous, it must be considered scientifically unsound.

We found that, by reducing very much the temperature and by protecting the solution from the air so as to exclude this oxidizing environment, it was possible to obtain maximum and minimum results, from acidified cuprous and cupric solutions respectively, which were fairly close together. The average between these two was still much less than the amount corresponding to the silver voltameter. The obvious inference from this discrepancy was that the silver voltameter is itself erroneous, and deposits, for some reason or other, too much silver to correspond to the current.

The careful investigation of the sources of this inaccuracy, both from the study of earlier work and from our own experience, led us to conclude that the irregularities were caused by some unusual action at the anode, and hence it is obvious that by excluding this anode with the help of a *fine-grained porous cup* it was possible also to exclude the irregularities. Upon careful trial the porous cup was found to give desirably constant results, which were 0.082 per cent lower than the amounts of silver obtained with the same current from Lord Rayleigh's standard. This amount, as is indicated below, was just enough to account for the discrepancy noticed in the work upon copper. It was found in the same way, that Patterson and Guthe's method yielded a result about 0.2 per cent higher than the porous cup voltameter. Upon applying these corrections to the chief results which have been obtained for the electrochemical equivalents of silver, it was found that all of the results were fairly concordant, indicating a deposit of about 1.1172 milligrams of silver per ampere per second.

Since the electrochemical equivalent of copper upon the same basis was found to be equal to about 0.3292 milligram per ampere per second, and since the atomic weights of silver and copper and silver are respectively 107.93 and 63.604, it is clear that Faraday's Law is verified more precisely than before. For $1.1172 : 0.3292 = 2(107.93) : 63.60$.

Conversely, supposing Faraday's Law to hold rigidly, and the value 63.60 to represent the atomic weight of copper, the agreement furnishes evidence of the accuracy of the new method.

3. *Irreversible Radiation Phenomena.*—An important theoretical article on this subject has been published by Professor MAX PLANCK. It is a study of the application of the electromagnetic theory of light to the laws of thermodynamics. The author recognizes the fact that since the phenomena of heat satisfy the second law of thermodynamics, the electromagnetic theory must also embrace this law in its generality. He discusses the phenomena of heat and light from the point of view of this theory; regarding the molecules as oscillating systems, sending out or receiving electrical waves, and he finds the necessity of enunciating electro-

dynamic laws analogous to the thermodynamic ones, for instance, laws of electrical entropy similar to that of heat entropy.

The necessity of such an extension of theory he illustrates by the following reference to spectrum analysis:

In the usual light theory, a bundle of rays of light, for instance that of the D line, is fully defined, if its plane of polarization, its color and intensity are given, together with its range of wave length. In the electrodynamic theory there is no such definiteness. Even if we take a millionth part of the visible spectrum, with a vibration-interval represented by the ratio 1 : 1,000,001; the period of the wave must be selected from all waves comprised between 510 billion and 510,000,510,000,000, that is from 510 million different vibration-periods. If the electric force is developed as a function of the time in a Fourier series, these 510 million vibration numbers will enter, for the determination of which we have only the intensity and the breadth of the spectrum of the ray. The author proceeds to develop the theory and to show the necessity of electrodynamic relations, analogous to the thermodynamic ones already recognized in the subject of heat.—*Ann. Phys.*, i, No. 1, pp. 69-122, 1900. J. T.

4. *A Radio-active Substance emitted from Thorium Compounds.*—Professor RUTHERFORD of McGill University, Montreal, has discovered that thorium compounds continuously emit radio-active particles of a certain kind which retain their radio-active powers for some time. This emanation has the power of ionizing gas and of passing through thin layers of metal and through layers of paper. He considers the question of the origin of the emanations and finds that they are not due to dust particles. They may, however, be due to vapor given off by the compounds. The evidence on this head is negative. The compounds have the remarkable property of producing radio-activity in all substances on which the emanation falls. This power lasts for several days and the radiation is of a more penetrating character than that of thorium or uranium, and thus has properties which thorium itself does not possess.—*Phil. Mag.*, Jan. 1900, pp. 1–14. J. T.

5. *Nature of White Light.*—M. E. CARVALLO believes that white light cannot be expressed by the usual formula $\epsilon^{-kt} sinht$, which denotes a damped vibration, for he finds that this gives a maximum of intensity which does not agree with the results of Langley and Mouton. Moreover when this formula is used in the theory of the grating white light results and not colored spectra. The error comes from retaining only those radiations which are sensible to the eye and in neglecting those intensities which are spread out in all azimuths.—*Comptes Rendus*, No. 2, Jan. 1900, pp. 81–82. J. T.

6. *New Electrical Condenser.*—BRADLEY has discovered a new substance which has a specific inductive capacity fifteen times greater than paraffined paper and about nine times greater than that of mica. The material is stearate of lead (stearinsaures Blei).—*Zeitshrift für Instrumentenkunde,* Dec. 1899, p. 215.

J. T.

7. *The Kinetic Theory of Gases. Elementary Treatise with Mathematical Appendices;* by Dr. OSKAR EMIL MEYER. Translated from the second revised edition by ROBERT E. BAYNES; pp. 472. London, 1899 (Longmans, Green & Co.).—The first edition of Dr. Meyer's work appeared in 1877, when the Kinetic Theory of Gases had just been fully developed. It was an admirable discussion of the subject at that time, and for the ordinary student of physics or chemistry had the great advantage of being presented in a readily intelligible form and not simply from the mathematical standpoint. This first German edition has been widely and favorably known in England and this country. Now, after the lapse of more than two decades, in which the theory has been perfected and at the same time the difficulties involved in it have been clearly shown, Dr. Meyer brings out a second edition, presenting the same subject as it stands to-day. The plan of the earlier work has been retained, the body of the volume containing the general discussion and the mathematical treatment being given in the series of appendices. This, as will be seen, at once meets the needs of all classes of readers. The work is so well known that special discussion of its contents, or comment upon the clearness of the treatment, hardly seem required. The English translator has performed important service in presenting the work to students in England and America in their own language. The translation has had the advantage of some additions and modifications suggested by Prof. Meyer, under whose eye the proofs have passed.

8. *The Rise and Development of the Liquefaction of Gases*, by WILLETT L. HARDIN, Ph.D., Harrison Senior Fellow in Chemistry in the University of Pennsylvania; pp. 250. New York, 1899 (The Macmillan Co.).—An evidence of the wide interest felt in scientific subjects at the present time is given by the fact that when a new subject is rapidly developed, it is not long before a comprehensive volume giving the main facts regarding it is available for the general public. The present volume is a case in hand, and in preparing it the author has performed a service to the many interested in the past history of this subject, in its present development and also in the possibilities for the future, a topic somewhat imaginatively treated by the public press. From the early days of Boyle and Mariotte, he passes on to the classical work of Faraday and Andrews, and then to the more recent labors of those who have proved that the so-called permanent gases have no existence, the last steps being the liquefaction and solidification of hydrogen by Dewar. This volume should be read with interest by a wide circle of readers.

9. *An Introduction to the Study of Central Station Electricity Supply*, by ALBERT GAY and C. H. YEAMAN; pp. 467. London, 1899 (Whittaker & Co.).—This excellent work is one of a series of volumes prepared expressly for electrical engineers; it gives a clear and thorough statement of the many branches of work involved in the supply of electricity from a central station.

It has the somewhat unusual merit of having been prepared by authors who are themselves engaged in practical work, and consequently fully alive to the needs of others in the same line. It is comprehensive in scope, discussing the municipal relations of the work, the practical questions of building, as well as the more special topics of systems of supply, forms of steam generators, and the electrical equipment in general. The best forms of switch-boards and regulators are described, the methods of distribution with the various mains, etc. A chapter is given to the methods of charging for electrical energy, and the price involved; also another to the analysis of cost of management in its different departments.

10. *Annalen der Physik.*—The time-honored periodical, which for more than a century under the charge of Gren, Gilbert, Poggendorff and the Wiedemanns, has done so much for the development of physics, begins its fourth series with the first number for 1900. The title has been changed in recognition of the fact that the journal is now devoted to physics exclusively, and it is for the future to be edited by Dr. Paul Drude in Leipzig. The general interests of the journal will be cared for by the following gentlemen: F. Kohlrausch, M. Planck, G. Quincke, W. C. Röntgen, E. Warburg; of these M. Planck assumes special responsibility; they will be supported by the Deutsche Physikalische Gesellschaft.

II. Geology and Mineralogy.

1. *The Geology and Physical Geography of Jamaica; Study of a Type of Antillean Development.* Based upon Surveys made for Alexander Agassiz. By Robert T. Hill. With an Appendix on some Cretaceous and Eocene Corals from Jamaica. By T. Wayland Vaughan. Bull. Mus. Comp. Zool., Harvard College, vol. xxxiv (Geological Series, vol. iv,) plates i–xli, figures 1–40, pp. 1–256, 1899.—Jamaica, as the central land-mass of the American Mediterranean region, has been chosen by Professor Agassiz for thorough geological investigation. "This central position of the island is important from geographic, biologic, and geologic points of view, and makes it a typical base of study for one interested in Antillean problems. Like a measuring gauge set up in the middle of a stream to record the rise and fall of a river, it stands in the center of the American Mediterranean,—a standard geological index of the great oscillatory changes of level which have taken place in the history of Tropical America, whose feebler amplitudes only are indicated in the perizonal continental borders." Mr. R. T. Hill having made the necessary investigation of the geology of the island, presents in this volume an exhaustive account of the present geological condition of the island. From the facts gathered, the author has drawn the following conclusions regarding the known history of the Antillean region: "The geology and configuration present

no evidence whatsoever whereby past land connections can be established between these islands and the North and South American lands in Post-Jurassic time, especially in the Tertiary, Pleistocene, or recent epochs. The configuration and conditions of these islands in Pre-Jurassic time cannot even be surmised. There are some hypothetical and biologic reasons for believing that the outer rim of the American Mediterranean constituted a partial or complete bridge between the continents in Jurassic time, and that the Panama bridge did not then exist. The first definite evidence of Antillean lands is found in the eruptive rocks of late Cretaceous time, when it is probable that there were marine volcanoes. The land débris constituting the Eocene strata throughout the islands testifies the pre-existence of extensive Cretaceous land areas. There was a profound regional subsidence in late Eocene and early Oligocene time, which submerged all but the highest tips of the Antilles, and which extended to the margins of the surrounding continents. In late Oligocene or Miocene time there was a tremendous orogenic movement which resulted in uplift, whereby many of the islands were connected with each other, and possibly an insular southern portion of Florida, but not establishing land connection with the North and South American continents. In Miocene or early Pliocene time the islands were severed by submergence into their present outlines and membership, which they have since retained with only secondary modification. In Pliocene and Pleistocene time there have been intermittent periods of elevation without serious deformation, but not sufficient to establish land connections or to restore the island to the heights and areas of Mid-Tertiary time. The Pleistocene movements, while epeirogenic, were sufficiently differential to show that they were not uniform in all parts of the area, showing great differences in amplitude within the West Indian area, and were not harmonious with those of the North American coastal plain. The irregularities of the submerged configuration of the West Indian region are orogenic, and not due to submerged continental drainage systems. The elevated coral reefs of the West Indies were formed on rising lands." The volume is beautifully illustrated with numerous heliotype pictures of the important geological features of the island. W.

2. *Maryland Geological Survey.* Volume III; by WILLIAM BULLOCK CLARK, State Geologist, plates i—xxxv, pp. 11–461, and 3–80, 1899.—This report includes, in addition to the State Geologist's account of the organization of highway investigations, chapters on the following subjects: The relations of topography, climate and geology to highway construction, by William Bullock Clark; highway legislation, and its influence on the economic development of the state, by St. George Leakin Sioussat; the present condition, the construction and repairs of roads, by Arthur Newhall Johnson; and on the qualities of good road-metals, the methods of testing them, method and ex-

pense of road improvements, and the advantages of good roads, by Harry Fielding Reid.

In the excellence of paper, illustrations, and its general make-up, this volume maintains the high standard of previous volumes. If one part may be selected for special comment, it is Part IV, on the present condition of Maryland highways, written by Arthur N. Johnson, formerly connected with the Massachusetts Highway Commission. Based upon a thorough examination of the highways of Maryland, the report presents a very complete account of their present condition and future needs. In the latter half of the article, detailed information is given regarding the roads and their problems in each county, illustrated by colored geological maps of each county, with the roads marked in their relations to the geological formations. Detailed explanations are given of the position and use of different kinds of rock for road-making purposes. The combination of pure science and practical utility is here brought to a high degree of perfection and success.

W.

3. *A Memoir on the Paleozoic Reticulate Sponges constituting the family Dictyospongidæ;* by JAMES HALL and JOHN M. CLARKE. Memoir II, New York Geological Survey, 350 pages, LXX plates. Printed 1898.—This memoir* brings together into one volume of text and plates all that is known at the present time of this most interesting family of fossil sponges. Not only have the forms occurring within the limits of the State of New York been studied and fully illustrated, but comparisons have also been made with specimens from Pennsylvania, Ohio, and Indiana, as well as from Brittany, England, and Germany. In the desire to render the memoir as complete as possible, the authors have introduced some earlier forms, the grouping of which with the Dictyospongidæ may be doubtful, especially those founded on isolated spicules.

Other species described are omitted from the scheme of classification and lack positive evidence as to relationships. In completeness of description and illustration, the memoir is all that could be desired, but it may be regretted that more is not given in regard to the development of the individual and the intimate and necessary relationships between structure, growth, and form.

It is noted that the living sponge approaching nearest to the Dictyospongidæ is the "Venus Flower Basket," *Euplectella aspergillum.* Like *Euplectella* the fossil forms were thin-walled, vase-like sponges sustained by a delicate network of siliceous spicules, but in many details they departed from this modern representative. They measured from several inches to two feet or more in height and lived in colonies on the sandy and somewhat muddy bottoms which extended at comparatively shallow depths over southern New York, Pennsylvania, Ohio, and Indiana, during the Upper Devonian and Lower Carboniferous. Their exist-

* Briefly noticed on p. 69.

ing allies are most abundant in the more quiet waters with muddy bottoms, which form the deeper parts of the continental shelves.

As it is only in the rarest instances that the minute details of the spicular network are preserved, the separation of the fossil forms into species rests mainly upon more general characteristics. For the same reason a long time elapsed before the true nature of these fossils became evident. In 1842 Conrad described *Hydnoceras* as a cephalopod and subsequently these Hexactinellids were doubtfully grouped with the Algæ. It was not until 1881, nearly forty years later, that specimens were found at Crawfordsville, Indiana, showing the individual spicules and their spongious affinities.

Considering their fragile nature, their forms are remarkably well preserved. In some instances colonies were overwhelmed by a deposit of mud, at other times they were broken loose from their moorings before burial, but in both cases perfect molds have been left, showing not only the details of form but the *general* arrangement of the spicular network.

The form, which is the most important feature for the specific differentiation and generic delimitation of these fossil sponges, is subject to variation in several directions. The simplest type, and the most primitive as well, is a slender cone, narrow at the base and open at the upper margin. This may become almost cylindrical, as in *Dictyospongia*, or may expand into a wide saucer-like shape, as in *Hyphantœnia*. The next modification in form consists in the development of longitudinal ridges, thus breaking up the vase into pyramidal or prismatic faces. This prismatic type is determined by, and depends upon, the vertical bundles of spicules.

The bases of such sponges are conical, but as growth advances they pass into four-sided forms, due to four primary spicular bundles. Finally, as these diverge, four intermediate secondary bundles assume prominence, and the sponge becomes eight-sided, which is the normal prismatic form.

The sharpness of the prismatic angles diminishes toward the upper part of large specimens and they begin to show again the smoothness characteristic of their initial growth. Another variation in form is due to ring-like contractions at intervals along the cone or pyramid, giving a crenulated longitudinal outline. This is presumably acquired by an alternating contraction and expansion of the aperture as it grows upward, but to what extent the growth is confined to the upper part, as in corals, or to what extent there is a general expansion of the entire structure, is not discussed.

The prismatic and annular modifications combined give rise at their intersections to nodes, which in some species of *Hydnoceras* are merely blunt protuberances on the surface, but in others pass into sharp-pointed swellings of considerable elevation. The

extreme of nodal development is seen in *Botryodictya*, where these prominences become pendulous lobes arranged in numerous whorls along the cylindrical body of the sponge.

Lastly there may be modifications of the body into a stalk below and an expanded cup above, and again, as in *Phragmodictya*, there may be a basal disk for attachment, with a frill about the margin, the general effect resembling a sea-anemone in basal outline.

The spicular network gives the clue to classification. The family, as now defined, falls under the subclass Silicea and the order Hexactinellida. Since the elements of the spicular bundles are not fused together, the family further belongs in Zittel's suborder Lyssacina. The specimens from New York and Pennsylvania are molds and it is extremely rare to find the individual spicules preserved, but in the examples from Crawfordsville, the spicules, which in all siliceous sponges are composed of hydrated amorphous silica, have here been altered to pyrite, and this has often escaped oxidation. The conspicuous feature of the skeletal frame is the inner meshwork surrounding the gastric cavity, which has been already alluded to in discussing the pyramidal forms. This meshwork consists of horizontal and vertical, narrow and often flattened bundles of rod-like spicules, regularly spaced and forming a pattern of squares over the entire surface. These primary squares, which may be upward of an inch in diameter, are bisected by secondary spicular bundles and these in turn are subdivided until a fine network of squares, which may be of the sixth order, is reached.

The vertical spicular bundles extend the entire length of the sponge and the horizontal ones form complete rings. The memoir does not go into the genesis of the individual spicular rods and perhaps with the character of material available nothing definite could be learned regarding it. As commonly seen, these rods are hair-like and are spoken of as diactins, though it is possible they may be tetractins in which the rays become enormously elongated, and in growing parallel and adjacent to one another form the bundles. The entire thickness of the wall is slight compared with the diameter of the vase. The interior surface is formed of the rectangular network, while the outer surface contains large, free pentactins standing opposite each intersection of the spicular bundles. Various forms of smaller modified hexactins have been noted scattered among those of normal character. The fossils sometimes show tufts of rod-like spicules protruding half an inch or more from the nodes.

The preceding notes have been based on the Devonian Dictyospongidæ. Having obtained an idea of their characteristics, it may be well, in order to bring out the progress in differentiation shown within this family, to point out the striking features of the Lower Carboniferous forms and their derivation from Devonian ancestors.

In the lowest sub-Carboniferous faunas, the Waverly and

Keokuk, this progressive differentiation is most striking, the genera departing more widely from each other than in any previous epoch. The most notable character of these faunas is the loss of the prismatic form in many genera and the assumption of flowing outlines. Many Upper Devonian species show the tendency toward this feature in the smooth upper part of the vase in old individuals. The loss of the prismatic angles is a result of equalization of growth among several of the higher orders of spicular bundles. While this tendency is an approach to the simple primitive type, peculiar modifications have taken place in other directions. In the earlier, nodose forms, the nodes were clearly determined by the intersection of primary, vertical spicular bundles and annular enlargements.

In the Lower Carboniferous genus *Cleodictya*, on the contrary, a whorl of rounded obtuse nodes persists near the base, but these are no longer determined, as formerly, by prominent spicular bundles, the entire reticulum being a uniform fine meshwork. It is an interesting instance of the persistence of a feature after the determining cause had vanished. Another noteworthy modification appearing for the first time is the checkerboard surface of *Physospongia*. In this genus, every alternate square is raised, blister-like, above the general surface of the network, and the intermediate squares are depressed an equal amount. The effect is that of a checkerboard in which the squares of one color should be raised and those of the other color sunk below the general level of the dividing lines. Although this gives a nodose appearance, it is seen to have no relation to the nodose forms of the earlier genera.

Still another line of modification is seen in *Clathrospongia*. Here the spicular bundles become horizontal and vertical plates, perpendicular to the body-wall, changing what was originally a network into a series of pigeon holes, in which primary, secondary, and tertiary partitions can still be recognized. The depth of the wall increased until it finally equalled a quarter of the radius of the vase.

It yet remains to trace the subsequent history of this ancient family of sponges and to work out their relationships with the Dictyonine Hexactinellida of later periods. Although in some respects these ancient vase-like sponges were quite ornate and showed much differentiation, their primitive character is seen in the skeletal details and general form.

The spicules were not fused together as in the majority of modern Hexactinellids, but even in the spicular bundles maintain their individuality. In the mature stages of *Euplectella* and certain other existing genera there is a terminal sieve-like plate extending across the upper part of the cup which does not show a direct derivation from the walls. In the *Dictyospongidæ*, there is no evidence of such a modified protective structure. The most specialized feature of this family is the basal disk of *Phragmodictya*. In this genus the body-wall is cylindrical and the base is

a flat cone or plate, the irregular spicular bundles of which are continued into the upright wall of the sponge. Around the edge of the base is a frill extending outward and offering a broader surface for attachment, but this also is merely an extension from the main wall. It is possible that the spicules of the Dictyospongidæ never attained the complex and striking development found in the sarcode of living Hexactinellids.

While these features of recent species are indicative of their later geological age, and although they have lost some of their primitive simplicity, it can hardly be said that they have made any positive advancement. On the contrary, when we consider the maximum size, variety of form, and abundance of species characterizing the Upper Devonian and Lower Carboniferous, it must be concluded that these periods witnessed the culmination of the Lyssacine Hexactinellida. J. B.

4. *International Congress of Geology*—The eighth session of the "Congrès géologique international" will be held in Paris during the coming August, 16–28, in connection with the Exposition Universelle. The sessions open on the 16th in the pavilion of the Exposition, and close on the 28th, but will not be continuous, several days during the period being reserved to permit the members to visit the Exposition. It is proposed to have the meetings divided into four sections:

1. General Geology and "Tectonique."
2. Stratigraphy and Paleontology.
3. Mineralogy and Petrography.
4. Applied Geology and Hydrology.

A long and attractive series of excursions is announced, each of them under able leadership; some of these, as to the Ardennes, Touraine, Brétagne, etc., will be taken before the Congress; others to the Tertiary of the Paris Basin during the sessions, and a longer series to distant points in the Alps, the Pyrénées, and elsewhere after the close of the Congress.

Members may secure hotel accommodations during their stay in Paris at reasonable rates through the agency of the Société des Voyages modernes, 1, Rue de l'Échelle, Paris. Correspondence should be addressed to the Secretary, M. Charles Barrois, Boulevard Saint Michel 62, Paris. The treasurer is M. Léon Carez; the president, M. Albert Gaudry, membre de l'Institut.

5. *Beiträge zur Geologie und Petrographie Chile's*; by F. von Wolff (Inaug. Diss. Berlin 1899, pp. 85).—The material upon which this work is based was collected by the late Dr. W. Moericke during his travels in Chili in 1896. A sketch of the general geology is given accompanied by a map upon which the petrographic localities are noted. The petrographic portion is divided into a description of the older rocks of the coastal zone, the eruptive rocks of the Cordilleran upland, the granular and porphyritic rocks of the Andean group and the later lavas of the Andean high plateau.

The Andean rocks, which consist chiefly, as might be expected, of the diorite-andesite group, are the most interesting and their

description is accompanied by several analyses which add greatly to the value of the work. L. V. P.

6. *Repertorium der mineralogischen und krystallographischen Literatur vom* d. J. Anfang 1891, bis Anfang d. J., 1897, *und General-register der Zeitschrift für Krystallographie und Mineralogie, Band XXI–XXX.* Herausgegeben und bearbeitet von E. WEINSCHENK und F. GRÜNLING. I Theil. Repertorium von E. Weinschenk; pp. 354. Leipzig, 1899 (Wilhelm Engelmann).—The appearance of the first part of the third general index (vols. xxi to xxx) to Groth's Zeitschrift brings before the mind the long series of volumes, thirty and more, which mineralogists owe to the indefatigable labors of the able editor since the enterprise was inaugurated in 1877. This has been a period of great activity and important advance in mineralogy and to this end the *Zeitschrift für Krystallographie* has contributed a large part. The fact that it has given from the beginning a remarkably complete summary of all mineralogical literature makes this Repertorium by Dr. Weinschenk of great value. The second part is promised soon.

7. *Handbuch der Mineralogie;* von Dr. CARL HINTZE. Erster Band. *Elemente, Sulfide, Oxyde, Haloide, Carbonate, Sulfate, Borate, Phosphate. Vierte Lieferung;* pp. 481–640. Leipzig, 1900 (Veit & Comp.).—All mineralogists will welcome another part of Hintze's Mineralogie, which forms the sixteenth Lieferung thus far published. It is devoted to the simple sulphides, the species of galena, chalcocite and sphalerite being discussed with especial fulness.

8. *Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex;* von Dr. J. L. C. SCHROEDER VAN DER KOLK; pp. 48. Wiesbaden, 1900 (C. W. Kreidel).—This paper has been republished from the pages of the *Zeitschrift für analytische Chemie.* It consists chiefly of mineralogical tables in which the species are arranged according to their refractive indices, the first and longest table being divided into two parts, of which the first includes species with indices from 1·34 to 1·83: the second those with indices higher than 1·83. Those between 1·83 and 1·93 are further subdivided, as isotropic, uniaxial, and biaxial. In each case, after the name of a species, a brief statement is made in regard to its composition and prominent physical and chemical characters. A supplementary table gives the minerals arranged according to Groth's Tabellarische Uebersicht, with indices added. The introductory portion discusses the author's method of obtaining the approximate values of the indices of a given crystal or crystal fragment by immersing it successively in various solutions whose refractive power is known and noting whether its outline is marked, because of total reflection, by a more or less prominent dark (or colored) border until this finally disappears, when the indices of crystal and solution correspond.

III. Botany.

1. *Beiträge zur Physiologie der Wurzeln;* by Aug. Rimbach. (Berichte d. Deutsch. Botan. Gesellsch., vol. xvii, Berlin, 1899, p. 18.)—The morphology and physiology of the root is a subject that has been studied comparatively little heretofore, and the author is one of the few botanists who have called attention to the fact, that roots in many cases exhibit almost as many and as significant modifications as exist in stems and leaves. Roots are often looked upon as simply "nutritive," and are generally passed by in morphological and anatomical studies; in systematic works they as well as rhizomes are as a rule neglected. It is, therefore, the more interesting to learn something about these organs, which the author has studied very carefully for several years in the laboratory and in the field. He proposes four types: nutritive-, attachment-, contractile- and storage-roots. Roots of the first type are characterized by possessing no very pronounced power of resistance, since they have no stereïds, nor are they contractile nor especially adapted to store nutritive matters. Their only function is evidently to absorb and conduct nutrition. Certain plants possess no other roots than these, e. g.: *Dentaria*, *Corydalis cava*, *Paris*, *Tulipa* and others. Such roots are generally more slender than others. The cortical parenchyma is very poorly developed and does not persist for any considerable length of time. Furthermore, they are very plastic, being able to change their direction of growth in accordance with the local surroundings,—the conditions of the soil, for instance. Not uncommonly, however, this same structure may be recognized near the apex and in the minor ramifications of roots of the other categories. As a second category are to be distinguished such forms of roots as do not store nutritive matters and are not contractile, and in which the power of absorption is so small that their only, or at least most important, function seems to consist in attaching the plant to the substratum. These roots are named "attachment-roots." They are rare and may be found, for instance, in the epiphytic *Bromeliaceæ*. Considered from an anatomical point of view, these roots are very rich in stereome, while the cortical parenchyma is relatively poorly developed and frequently collapses. There are, however, certain roots which besides a purely mechanical function, also possess power of absorption. Such modifications are especially characteristic of *Palmæ*, *Gramineæ*, *Cyclanthaceæ* and *Araceæ*, epiphytic as well as terrestrial. The contractile roots constitute the third category. Their main function lies in their power of contracting and thus drawing the shoot deeper and deeper down into the ground. These roots have very little or no sterome, but possess an enormously developed thin-walled parenchyma, which persists through a long period of the plant's life. They are especially well represented in *Scilla*, *Ornithogalum*, *Crocus*, *Gladiolus* and *Oxalis*.

The contractile power of these roots does not always have the result of drawing the shoot deeper into the ground, but may, as in *Scrophularia nodosa*, merely serve to keep the shoot in place. In such cases contractile roots assume a function that belongs properly to the true attachment-roots, which lack contractile power. Storage-roots are such roots as possess a large persistent parenchyma, in which nutritive matters are stored. Such roots often become tuberous by the excessive development of this parenchyma. They are well known in various species of *Aconitum*, *Hemerocallis*, *Orchis*, many *Melanthaceæ*, etc. Some of these roots may at the same time be contractile, as for instance in: *Succisa*, *Plantago*, *Anthericum*, *Veratrum*, etc. The author also describes various phases of the biology of the root, such as longevity, ramification, periodical development, and the occurrence of different root-systems in the same species, which include many points of interest and importance. The paper is a highly welcome contribution to our knowledge of the root, in its structure and functions, and deserves to be studied carefully. T. H.

2. *Die Keimung der Samen von Anemone apennina;* by Fr. Hildebrand. (Berichte d. Deutsch. Botan. Ges. Berlin, 1899, p. 161.)—The author describes a very singular manner of germinating, as exhibited by *Anemone apennina*. The cotyledons possess long petioles, which have grown together in their entire length and pass gradually over into an almost globular tuber, which represents the axis of the seedling; the primary root develops from the base of the tuber. So far the seedling reminds us very much of that of *Eranthis hyemalis*. But, during the first season, the author noticed that the basal part of the cotyledonary petioles attained a darker color, and that not only hairs developed, but even secondary roots; besides, an anatomical examination proved this same basal part to possess the structure of a root with only one central mestome-bundle. The seedling exhibits thus the singular case that the basal portion of the grown-together, cotyledonary petioles develops as a root, with its structure and function. During the first year the seedling develops the first proper leaf, which is green and which appears from the apex of the tuber. It might seem, at a first glance, more strange than it really is that roothairs and roots should develop from the cotyledonary petioles, yet we must remember that even petioles of various plants may be easily forced to produce roots by means of artificial culture. A close relative of this *Anemone*, *A. blanda*, does not exhibit this manner of germinating. A tuber is developed in this species and the petioles of the cotyledons grow together, but no roots or hairs develop from their bases, and the first proper leaf does not appear until the following year, while in the former species it developed contemporarily. T. H.

3. *Die Carex-vegetation des Aussertropischen Südamerika* (ausgenommen Paraguay und Südbrasilien); by Georg. Kükenthal. (Engler's Jahrb, vol. xxvii. Leipzig, 1899, p. 485.)—Sixty-

one species of *Carex* are enumerated from this part of South America, of which thirty are endemic and fifteen only known from tropical South America besides; four varieties are, moreover, not known from elsewhere, while the typical forms occur in the northern hemisphere;—*C. vulgaris* Fr. is the only cosmopolitan species among them. The systematic arrangement of these species is very interesting, and three subgenera are adopted: *Vignea*, *Vigneastra* and *Eucarex*. These are again divided into twenty sections, mostly those of Drejer, Fries and Tuckermann, while the subsections are arranged in accordance with the number and position of the spikes: monostachyous, homostachyous and heterostachyous, of which the first one is generally supposed to represent the oldest type.

The species are very carefully described in Latin, and a number of varieties are included. Synonyms are also given in connection with reference to literature, besides the habitat and geographical distribution. The author has beyond doubt been very successful in his attempt to classify this difficult genus in natural sections, similar to those suggested by Drejer as far as concerns the morphological characters, and the paper constitutes, therefore, an important basis for future research. However the morphological characters, striking as they may appear, are often very deceiving. We wish that the author had, at least to some extent, compared his morphological classification with such anatomical studies in *Carex*, of which the literature possesses such interesting and important contributions as those of Lemcke, Mazel and others. The external structure of utriculus, for instance, is often very uniform in many species, hence these are classified in one section, yet an anatomical study of this little organ reveals a number of striking divergences, which may prove useful not only in classifying the species among themselves, but also in establishing natural sections. T. H.

4. *A list of the plants of the Pribiloff Islands with notes on their distribution;* by JAMES M. MACOUN. (The Fur seals and Fur seal islands of the North Pacific Ocean. Part 3. Washington 1899, p. 559.)—A complete catalogue of all the plants that have been found on these islands since their discovery in 1786 is given in the present paper, the total number of Phanerogams amounting to 172; 3 species of *Equisetum*, 3 of *Lycopodium*, and 6 ferns besides a number of mosses, lichens and fungi, are recorded. Among the Phanerogams we notice several species as being circumpolar, for instance: *Saxifraga stellaris* var. *comosa*, *Chrysosplenium alternifolium*, *Eutrema Edwardsii*, *Hippuris vulgaris*, *Kœnigia islandica*, etc., the last being the only annual species. *Papaver Macounii*, *Cardamine umbellata*, *Chrysosplenium Beringianum*, *Primula Macounii*, *P. eximia. Polygonum Macounii*, *Elymus villosissimus* and *Carex Pribilovensis* are described as new, and the first six are, furthermore, figured. The paper constitutes a very important contribution to the knowledge of this flora, and it may be stated that the author has personally examined all the species included in the list. T. H.

5. *The Missouri Botanical Garden.*—The eleventh annual report, bearing date Jan. 10th, 1900, is at hand. Like its recent predecessors it contains a report of the officers of the Board of Trustees and the annual report of the Director. From these it is apparent that the assiduous care exercised by the Director has been fruitful in good results in every way. The Garden and the Arboretum continue in his charge to exert great influence, not only throughout that part of our West which has the good fortune to possess them, but throughout our whole country.

The scientific papers are: 1. A disease of Taxodium distichum, by Hermann von Schrenk. 2. Certain Agaves flowering in the Washington Garden in 1898, by J. N. Rose. 3. A revision of certain American species of Euphorbia, by J. B. S. Norton. 4. A revision of the species of Lophotocarpus of the United States; and description of a new species of Sagittaria, by Jared G. Smith. All of these are valuable papers. The first one men tioned was Dr. von Schenck's Thesis for his doctorate. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *Report of S. P. Langley, Secretary of the Smithsonian Institution, for the year ending June 30th, 1899;* pp. 81. Washington, 1899.—The report of an institution at once so active and so useful as the Smithsonian is always of interest. The various matters of administration are here discussed in detail and also the special lines in which the institution is able to promote scientific research. One of the most important of these is the work made possible through the Hodgkins fund, under the auspices of which a series of different investigations have been carried on. The development of the National Zoological Park is spoken of and also the work of the Astrophysical Observatory. A series of appendixes give further detailed statements in regard to the various subjects by the different gentlemen in charge. From the report of Mr. C. G. Abbot, in charge of the Astrophysical Observatory, we quote extensively in another place (p. 214).

2. *Report of the United States National Museum.* Part I, pp. xxvii, 1021. Washington, 1899. (Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the Iustitution for the year ending June 30th, 1897.)—This volume contains the report of the coudition and progress of the United States National Museum to June 30th, 1897, by Charles D. Walcott, in charge. A detailed account is given of the numerous additions to the various collections and of the extensive work of exploration and investigation that has been carried on under the auspices of the Museum. Part II contains papers upon certain portions of the collections. Of these may be mentioned, one on Recent Foraminifera, by James W. Flint, pp. 249–349, illustrated by eighty plates; also

two papers interesting to mineralogists, by Wirt Tassin, one a catalogue of a series of specimens illustrating the various properties of minerals; and a second, the detailed system of classification of species adopted in the Museum. The remaining papers are upon ethnographical subjects; one of these, by J. D. McGuire, describes the pipes and smoking customs of the American aborigines; another, by Thomas Wilson, describes pre-historic arrow-points, spear-heads, and knives. Both of these are fully illustrated and will be found interesting by those at work in this department.

3. *Maryland Weather Service;* Vol. I. William Bullock Clark, Director; pp. 1–566. Baltimore, 1899 (The Johns Hopkins Press).—This first volume of a new series of reports on the Maryland Weather Service maintains the high standard set by the other Maryland scientific publications under the direction of Professor Clark. The Board of Control of the Maryland Weather Service consists of the Director; the Secretary and Treasurer, Milton Whitney, representing the Maryland Agricultural College; and the Meteorologist, F. J. Walz, detailed by the Chief of the U. S. Weather Bureau. Volunteer observers scattered throughout the twenty-three counties of the state assist in the work, reporting regularly to the meteorologist. The field laid out for investigation is very broad and gives to the weather service an unusual scope, so that valuable results may be looked for. The present volume opens with an Introduction by the Director. Part II, pp. 41–216, following is devoted to a general report on the physiography of Maryland, by Cleveland Abbe, Jr. This is an interesting discussion of the development of the important features of the different provinces in the State, the Coastal Plain, the Piedmont Plateau, and the Appalachian Province. Part III, pp. 219 to 548, contains the Report on the Meteorology of Maryland by Cleveland Abbe, F. J. Walz and O. L. Fassig, which has already been noticed in this Journal (p. 81).

4. *The International Monthly.*—This new periodical, "A Magazine of Contemporary Thought," has recently been inaugurated. It is published at Burlington, Vermont, by the Macmillan Company (of New York), and is under the editorship of Frederick A. Richardson; the advisory board includes a large number of well-known names at home and abroad in a wide range of departments. The two numbers already issued show an active treatment of live subjects; two of the articles included are of scientific character.

5. *Histoire des Mathématiques;* by Jacques Boyer. Pp. 256, with 19 portraits and 7 facsimiles of manuscript. Paris, 1900 (G. Carré et C. Naud). This work forms a volume of the *Bibliothèque de la Revue Générale des Sciences*, and presents in brief outline the history of Mathematics from Ahmes to Lobatchewsky. Where so much is comprehended the compression is necessarily great. Thus China, Babylon, Chaldea and Eygpt occupy but seven pages. But by help of a vigorous style and judicious selection with the avoidance of technicalities, the

author has produced a volume that can be read with much profit and without fatigue by any cultivated person.

6. *The Earth Measured.* By a member of the Chicago Mathematical Society. Pp. 40.—A useful collection of the results of geodetic measurements with related quantities for Sun, Moon and Jupiter.

7. *Leitfaden für den Unterricht in der anorganischen Chemie.* Didaktisch bearbeitet von Dr. Joachim Sperber. Erster Teil. 8vo, pp. vi, 120. Zürich, 1899. (E. Speidel.) Mks, 2.40.—The first part of a simple laboratory manual used by the author with his own classes and serving as a guide to the more elementary physical experiments. These are well described and fully illustrated; in some cases with full page cuts. G. F. B.

8. *La Tension de dissociation avant H. Sainte Claire Deville.* Introduction par P. Duhem à une memoire *De l'influence de la pression sur les actions chimiques.* Par Georges Aimé (1837). 8vo, pp. 32, Paris, 1899. (A. Herrmann.)—This brochure is intended to clear up a historic point in science. The thesis of Aimé printed in 1837, as Duhem states in his introduction, seems to show clearly that this physicist had conceived the idea of a dissociation tension thirty years before it was developed by Debray and Deville. G. F. B.

OBITUARY.

Professor HENRY ALLEN HAZEN, of the Forecast Division of the U. S. Weather Bureau, died suddenly at Washington on January 23d, as the result of an accident. He was born January 12, 1849, in Sirur, India, the son of missionaries of the Congregational church. He came to this country when ten years old and was educated at St. Johnsbury, Vermont, and at Dartmouth College, where he was graduated in 1871. After this for four years he was instructor in drawing in the Sheffield Scientific School at New Haven, and subsequently was assistant in meteorology and physics under Professor Elias Loomis, being associated with him in meteorological researches and the preparation of his "Contributions to Meteorology." In May, 1881, he became connected with the Signal Service and took a prominent part in the development of the scientific work of the Bureau in accordance with the plans of the chief signal officer, Gen. William B. Hazen. Besides the work specially belonging to him, as the deduction of altitudes by railroad levels, the study of the psychrometer, the proper exposure of thermometers, the study of thunder storms, etc., he devoted himself also to such subjects as barometric hypsometry and the reduction to sea level, the testing of anemometers, the study of tornadoes and the theories of cyclones, atmospheric electricity, balloon ascensions, the influence of sun spots and the moon, etc. During the administration of General Greely, he became a junior professor at a higher salary and was assigned to official duties of broader aspect. He frequently took his turn as forecast official

and as editor of the Monthly Weather Review, also acting as assistant in the Records Division. In July, 1891, on the transfer of the service to the Department of Agriculture he was appointed one of the professors of meteorology in the Weather Bureau, where he was at once assigned to regular and congenial duties in the Forecast Division.

His name is connected with the "Hazen Thermometer Shelter," which being shown to be better than the large close double louver formerly used, was adopted by the Bureau in 1885 and still remains in use. His experimental work with the sling psychrometer and dew-point apparatus was executed with great care and refinement, but the resulting psychrometer formula differs from those in current use in that it rejects the important term depending on the barometric pressure. Among his larger publications were "The Reduction of Air Pressure to Sea-level" and "The Climate of Chicago." In addition to his official work in the Weather Bureau, he was a frequent contributor to meteorological and other scientific journals. He was one of the supporters of "Science" during the years 1882–89, and of "The American Meteorological Journal," 1884–96. This Journal, between 1881 and 1887, contained a number of papers by him. He also published, independently, works entitled "Meteorological Tables" and "The Tornado."

Professor Hazen was a man of strong convictions and thorough sincerity; he had an indomitable will, abundant energy and immense powers of work. His tenacity of purpose, independence and strength of feeling may have made him at times appear obstinate in adhering to his own position as against those who held different views, but his character was true and his amiable and lovable disposition he showed to those most closely associated with him. His sudden death is a great loss not only to his personal friends, but to the Department which he served so faithfully.

Dr. Hanns Bruno Geinitz, the veteran German geologist, died at Dresden on January 28th in his eighty-sixth year. Half a century has passed since he was made (1850) Professor of Mineralogy and Geognosy at the Polytechnic School in Dresden; a little earlier (1846) he was placed in charge of the Dresden Mineralogical Museum, of which he later (1857) became Director. To these duties he devoted himself with great energy, but in addition he was ever active, nearly to the close of his long life, in original investigations in geology and paleontology, and the list of his publications includes many and valuable papers; the first of these bears the date of 1839. He was a man of charming personality, alike respected by his scientific colleagues and beloved by his personal friends.

Professor David E. Hughes, F.R.S., the English physicist, well known for his invention of a widely-used type-printing telegraph system, also for his work in connection with the microphone, induction balance and other physical instruments, died on January 22d at the age of sixty-eight years.

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FOURTH SERIES.

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WITH PLATES II–IV.

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1900.

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The firm of A. E. Foote seldom needs introduction to readers of the "AMERICAN JOURNAL OF SCIENCE." Founded at Philadelphia in 1876 by the late Dr. Foote, it has grown steadily in size, quality and variety of its stock of mineral specimens, and in the extent and volume of its trade. Prize exhibits have been made at four large Expositions in the United States, and at the great Expositions of London and of Paris ('89), making the name generally known among mineralogists throughout the world. As an indication of this it may be added that the European trade in cabinet specimens, conducted from our Philadelphia store in recent years, has about equalled our American sales. To-day we have three experienced mineralogists in the field, collecting and buying exclusively for us. Two of them are continually travelling; one in the United States, one in Australia. It is evident that this affords unequalled facilities for the accumulation of choice and fresh material, to a degree unprecedented in mineral dealing.

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APRIL 1ST, 1900.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXIII.—*The Skull, Pelvis, and Probable Relationships of the Huge Turtles of the Genus Archelon from the Fort Pierre Cretaceous of South Dakota;* by G. R. WIELAND. With Plate II.

THE marine turtles of the Fort Pierre Cretaceous of South Dakota not only represent the most gigantic species known, but also are of much importance as including undoubted descendants of *Protostega* from the underlying Niobrara Cretaceous, in common with which they may be regarded as ancient relatives of *Dermochelys*.

The first of these turtles was discovered and collected by the writer in 1895. The nearly complete carapace, pectoral girdle and limb bones of this specimen were described in this Journal (13)* the year following as those of the new genus and species *Archelon ischyros*. Additional material collected in 1897 and 1898, and in part here described, proves this determination to have been correct, although in describing the fine plastron of the first specimen secured the generic name *Protostega* was needlessly substituted (15). This was done in deference to high authority, but careful comparison made possible by new material of both *Protostega* and *Archelon* places beyond further question the validity of the latter genus.

The Skull of Archelon Ischyros Wieland.

The skull, the description of which is here given, was secured by the writer in the summer of 1897, and belongs to the second specimen discovered, this being nearly complete. Notwithstanding its gigantic size, it represents a turtle only three-fifths as large as specimen I. A fragmentary specimen (III)

* See references on p. 250.

indicates a turtle 4·25 meters long with a cranial length of fully 1 meter.

1

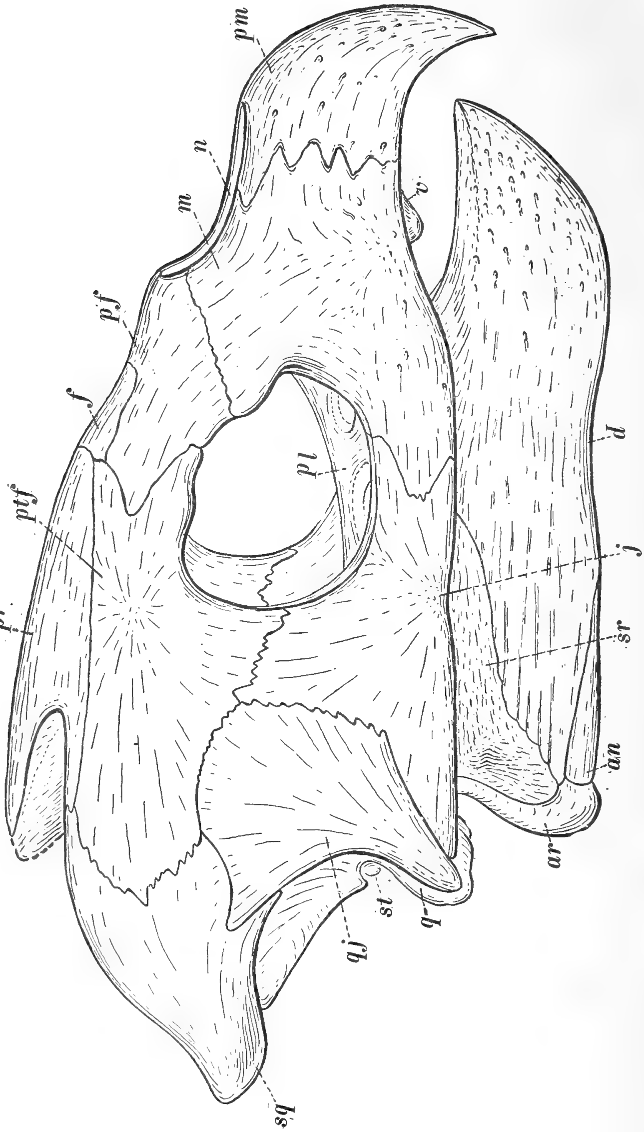

FIGURE 1. Skull of *Archelon ischyros* Wieland, $\times \frac{1}{5}$; *an*, angular; *ar*, articular; *d*, dentalium; *f*, frontal; *j*, jugal; *m*, maxillary; *n*, external nares; *pf*, prefrontal; *pl*, palatal; *pm*, premaxillary; *pr*, parietal; *ptf*, postfrontal; *q*, quadrate; *qj*, quadrato-jugal: *sq*, squamosal; *st*, columella auris in stapedial notch; *sr*, surangular; *v*, vomer.

The main features of the present skull are well represented in Plate II, based on a photograph of it as excellently mounted

by Mr. Hugh Gibb, and now on exhibition in the Museum of Yale University. The plate is carefully interpreted in fig. 1. Still other features are shown in figs. 2 and 3, which are necessarily somewhat diagrammatic.

Notwithstanding considerable lateral compression of the posterier portions, this skull is an unusually good one, all the main details needed for a restoration being well preserved. It only fails in the region of the brain cavity and the posterior extremity and connections of the vomer. Its description and comparison with its nearest known relative and ancestor *Protostega gigas* from the Kansas chalk has been made all the more exact and satisfactory by the courtesy of Prof. W. M. Wheeler and Dr. E. C. Case, who generously placed in my hands for purposes of comparison the exceptionally fine material so ably investigated by the latter (5). This represents various disarticulated elements of the skull and a fine mandible. Between the two specimens the skull of these important forms of the Cretaceous may now be known with essential completeness. The description of parts follows.

The Premaxillaries.—These elements are strongly coössified and comparatively narrow laterally, but long and massive. The narial border is rounded and horizontal. The dental border is posteriorly less developed into a cutting edge than in other turtles, but anteriorly runs out into the most strongly decurved beak known in any turtle, the aspect being that seen in birds of prey. The surface of the beak especially is deeply pitted, and in life must have been covered by a horn sheath of the relative decurvature and strength of that of the eagle. There is only a shallow excavation for the reception of the mandibular beak.

The great length and other details are the exact antithesis of the short and notched premaxillaries of *Dermochelys* with a persistent suture. The inner features and union with the vomer are shown in fig. 2. The boundaries are, in spite of all disparities, essentially similar to those seen in *Dermochelys.*

The Maxillaries.—The general maxillary outline is that of a broad Y lying on its side, the fork forming the anterior orbital boundary, and the wide base extending forward to an unusual distance. Much of the great cranial length is due to the elongated maxillaries and premaxillaries.

The narial border is only moderately upcurved to aid in the formation of the greatly elongated external nares, which face upwards and but slightly forwards, being much more nearly horizontal than in most turtles.

The dental border is continued by the maxillary as a low cutting edge which soon becomes rounded and continues so to junction with the jugal. It should be noted here that the

entire dental border is peculiar; firstly, because of the decurved premaxillary; secondly, because of the very slight concavity of the vomeral region, and the continuation of the dental border of the jugal as a rounded edge, which instead of ascending is most depressed at its junction with the quadrato-jugal, as will be again noted in the description of the latter elements.

2

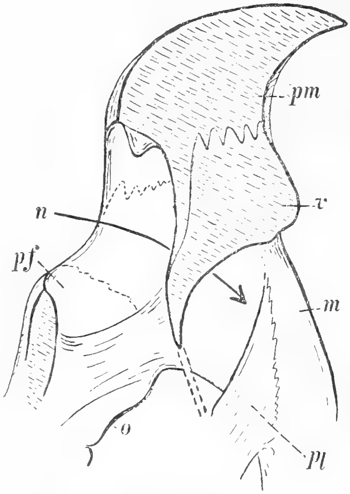

FIGURE 2. *Archelon ischyros* Wieland. Median vertical section through anterior region of skull $\times \frac{1}{5}$; *m*, maxillary; *n*, narial opening; *o*, orbital boundary; *pf*, prefronto-nasal; *pl*, palatal; *pm*, premaxillary; *v*, vomer.

The maxillaries do not rise as high relatively to meet the prefrontals as is usual. There is in this conformation a suggestive resemblance to *Lytoloma* (*chelone*) *longiceps* Owen.

The Jugals.—These elements are subtriangular in outline, the basal side being longest, and extending back to the lower extremity of the quadrato-jugal as an un-notched nearly straight, somewhat depressed and rounded border. The depression of the jugal is quite unique and gives great length to the unusual dental border thus formed.

With the postfrontal the jugal forms the posterior two-thirds of the orbit, the orbital border being distinctly flattened and from 2^{cm} broad posteriorly to $3{\cdot}3^{cm}$ broad anteriorly. Only the extreme anterior extension articulates with the palatal, making the boundaries those of *Thalassochelys* and not like those of *Dermochelys.*

The Quadrato-jugals (Paraquadrate of Siebenrock 12).—These bones present exteriorly a large gently convex surface of broadly crescentic outline. The concave posterior border stands at a right angle to the outer surface and is 4^{cm} broad, forming a symmetrical surface with the quite similar posterior orbital boundary noted above. See fig. 1.

The quadrate is fortunately present in the specimen of *Protostega gigas* studied by Case, who thus describes it (5, page 27): "The quadrato-jugal of the right side is triangular in general outline. The posterior edge is concave and the whole bone is convex from above downward. The superior edge is narrow, and there is no prolongation of the antero-inferior portion as in *Dermochelys* (5, Pl. V, fig. 7)."

The differences between these two quadrato-jugals are therefore striking. Firstly, the outer area of that of the present specimen, which as just stated is broadly crescentic in outline, is relatively more than double that of *Protostega*, which is isosceles-triangular in outline with the equal sides slightly concave. Secondly, the flat free posterior border just outside the articulation with the quadrate as seen in *Archelon*, is represented in *Protostega* by an oblique surface mostly taken up by the quadrate suture. Lastly, the articulations must be essentially different. Since the outline in *Protostega* is distinctly triangular, the union with the jugal and post-orbital is by two sutural lines making an angle of 60° with each other, instead of by a long curved sutural boundary as in *Archelon*. Now since the upper of these sutural lines is nearly horizontal, and the general outline in *Protostega* that seen in *Dermochelys*, it is probable that the latter and *Protostega* agree in squamoso-jugal union. On the contrary, in *Archelon* there is marked squamoso-jugal separation. For reasons which I have pointed out elsewhere I do not lay great stress upon squamoso-jugal union or non-union alone (13). But the more salient fact to be borne in mind is that the great differences in general conformation compel accompanying variations in the jugal, parietal, and squamosal which are fundamentally generic.

The Squamosal.—This element is also present in both the Kansas material and the present specimen. The anterior portion extends upward to meet the parietal as a long narrow band nearly covered by the post-frontal, and does not expand nearly so much as in *Protostega*. The articular surface for the quadrate is placed well up on the interior side, more as in *Dermochelys* than in either *Protostega* or *Thalassochelys*. The lower border is shallow sigmoidal in outline and the posterior extension instead of ending bluntly as in *Protostega* runs out into a heavy rounded point somewhat as in *Trionyx spinifer*. As in *Protostega*, there is however no posterior inferior grooving of this extension.

The Prefrontals.—These are somewhat rhomboidal in outline. The junction with the postfrontal is long and prominent, and much as in *Dermochelys*. Of the four elements bounding the orbit the prefrontal takes least part. The prefrontals extend much further back from the external nares than in *Dermochelys*, the general resemblances being intermediate to the latter and *Thalassochelys*.

The Frontals.—These bones are narrow and relatively elongate. As the cranial roof underwent some crushing, it is difficult to discern the precise position of the parietal boundary. Resemblances *Thalassochelan*.

The Postfrontal.—The markings and boundaries of this

element are very distinct. It has an especially broad posterior development. Anteriorly it is greatly strengthened by the heavy post-orbital border, which runs up internally as a sharp but heavy buttressing ridge full $2{\cdot}5^{cm}$ high in its middle part, and not disappearing wholly until the parietal is reached. No such ridge is present in *Dermochelys*, though a similar one of much less development is seen in *Thalassochelys*. The boundaries are approximately those of the latter form, union with the quadrato-jugal being very distinct.

The Parietals.—These were deeply escalloped posteriorly, nearly as much as in the *Chelydridæ*. As they had been subjected to crushing their outlines were not so distinct as in the case of the other external elements of the skull. Most unfortunately the vexed question as to descending processes of the parietals and parieto-pterygoidal union can not be definitely settled from the present specimen. There certainly was some, if not a strong development of these processes.

Both Baur and Case (1 and 5) have stated that there were strongly developed descending parietal processes uniting with the pterygoids in *Protostega*.

Whether or not the absence of these processes in *Dermochelys* is as important anatomically as convenient in classification, it is to be hoped that future material will determine what the exact condition was in these Dakota descendants of *Protostega*.

The Quadrates.—These are both present in fair condition and but slightly crushed out of their natural articulations. They are short and unusually massive, particularly the posterior border as it extends from the stapedial notch to the squamosal. A portion of the right stapes was still to be seen in the stapedial notch. As implied by the differences between the quadrato-jugal and squamosal of *Archelon* and *Protostega* as pointed out above, the aspect of the quadrate and its boundaries as seen in the present fossil must vary sharply from that of *Protostega*. The quadrates of the latter are illustrated by Case (5), while those of *Archelon* are seen as thrust slightly back in Plate II.

The Vomer.—The vomer is present in place and is remarkably developed. It is illustrated in fig. 2. As in *Protostega* (5) the anterior relations are distinctly *Dermochelan*, the vomer and palatines not roofing the posterior nares. But with these boundaries resemblance to this form ceases. Conforming to the great development of its anterior bounding elements, the vomer is unusually massive. It takes part in the palatal surface as a prominent conical projection in front of the posterior nares 2^{cm} high. Taken in conjunction with the descending premaxillary beak, this is quite the reverse relation to that seen in *Colpochelys Kempii* Garman, which has a flat

palate and no decurvature of the premaxillaries, but an upturned lower jaw with a prominent cone at the inner vertex of the ramial angle.

The superior surface of the vomer forms a distinct saddle contracting as it rises from beneath the overlap of the premaxillaries and passes back to support the inner buttresses of the prefrontals, between which it appears to end. Whether this was the natural condition could not be precisely determined. There is a bare possibility that the vomer did not pass back to form the usual vomero-palatal union. But whether this was the case, or whether the palatals sent a median branch far forward must for the present remain undetermined. The posterior nares however were not bridged by a nether vomero-palatal union, the condition being, owing to the deep gap between the palatals and the prominence of the vomer, intermediate between *Dermochelys* and *Eretmochelys*. Vomero-premaxillar union is stronger than in either the latter genus or *Argillochelys*.

Main Features of the Palatal Aspect.—These are distinctly shown in fig. 3. The only doubtful points are the exact size of the small basisphenoid and the boundaries in the vomero-palatal region just mentioned. Anteriorly the relations are partly *Dermochelan;* posteriorly they are *Thalassochelan*, with the exception of the basal processes of the basioccipital, which are heavy and project downwards and outwards as in *Dermochelys*. They are however much longer antero posteriorly than in this form.

There is a continual reminder that we have here to deal with a remarkable blending of the relations seen in the two genera just mentioned, with certain unusual characters. Especially the great development of the jugal nearly cutting out the quadrato-jugal in the basal view will be noted. Also the girder-like palatals are quite unique, forming a prominent

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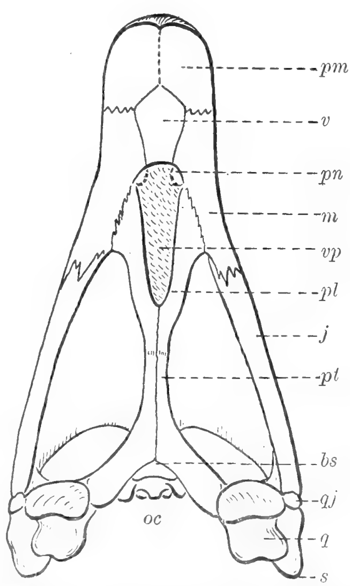

FIGURE 3. *Archelon ischyros* Wieland. palatal view × about $\frac{1}{10}$. *pm*, premaxillary; *v*, vomer; *pn*, posterior narial opening; *m*, maxillary; *vp*, the uncertain vomero-palatal region; *pl*, palatals forming a girder-like structure; *j*, jugal; *pt*, pterygoid; *bs*, basisphenoid; *qj*, quadrato-jugal; *q*, quadrate; *s*, squamosal; *oc*, occipital condyle.

V-shaped bridge, with any vomeral connection very deeply set in the skull. (Compare figs. 3, 4, and 5.)

*The Mandible.**—This was present in position and was quite perfect with the exception of the posterior elements of the left ramus, which were dissociated, only the surangular being recovered. The measurements appended may be taken as quite

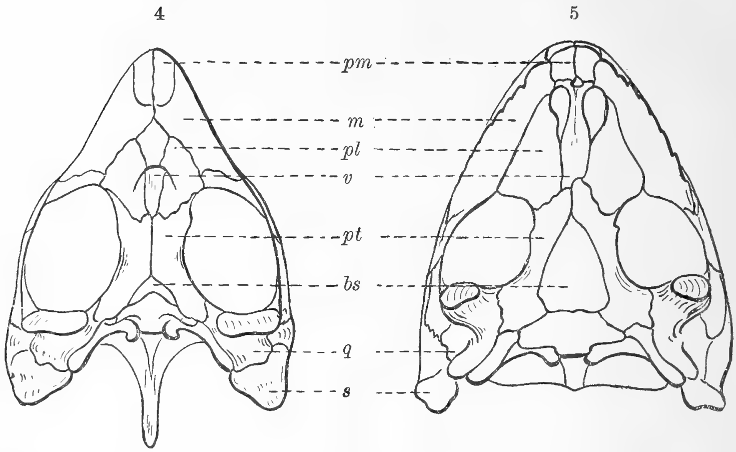

FIGURE 4. *Thalassochelys caretta*, palatal view of skull × 1/5.
FIGURE 5. *Dermochelys coriacea* " " " × 1/5.
pm, premaxillary; *m*, maxillary; *pl*, palatal; *v*, vomer; *pt*, pterygoid; *bs*, basisphenoid; *q*, quadrate; *s*, squamosal.

accurate, the complementary and articular being the only parts much altered by pressure. As the latter is very much flattened and the parts bounding it but little compressed, it may not have been well ossified.

From the apparent shortness of the rami, no less however than in the land turtle *Macrochelys Temminckii*, it may be fairly inferred that both the articular and the articular face of the quadrate were heavily encased in cartilage. This is also suggested by the roughened to spongiose appearance of both these parts. The horn sheath of the beak must also have been very heavy and somewhat upturned.

The general relationship of the present form to *Protostega* is strongly exemplified by the lower jaw. The presplenial of Baur (2) is however apparently less prominent than in that fossil (see Case, 5), the suture between it and the splenial not

* I retain the original nomenclature for the mandibular parts, not being as yet able to reconcile that proposed by Dr. Baur (2) with the conditions found in the Testudinata, and hoping later to present a paper on the homologies of the reptilian lower jaw.

being distinct. The presplenial region has rather the appearance of being a long anterior projection of the splenial (Baur's angular). On the contrary, the angular is a little broader and extends farther forward than in *Protostega*. Again, the narrow but nevertheless robust aspect of the anterior or symphysial portion of the dentary in *Archelon* is notable. Relatively to length the symphysial depth is great, and the weight of this portion of the jaw suggests a hammer-like action against the palatal cone. This would have been very effective in the crushing for food of large mollusca and crustacea, if perchance the Archelones were in any wise similar in feeding habits to existing carnivorous sea turtles.

Another well marked character is the persistent symphysial suture. While in half grown forms of *Protostega* this suture is wholly obliterated, in the present specimen, which may have been from adult to three-fifths grown, the rami readily separated on this line. So pronounced a suture is rare.

The ramial angle, which is 50° in *Thalassochelys* and *Dermochelys*, and 40° in *Protostega*, may not have been more than 25° in *Archelon*. The latter is a very narrow form, and the vertex of the rami forms a nearly sharp instead of rounded angle.

It is scarcely necessary to compare further. There is certainly more resemblance in the mandibulum to *Thalassochelys* than *Dermochelys*, but withal intermediate characters as in other parts of the skull.

General appearance of the skull.—The skull of *A. ischyros* is long in proportion both to the body and to its width, but nevertheless massive. There is in the deeply notched parietals, the decurved beak, and the depressed vicious-looking forehead, a distinct reminder of the features in such carnivorous land turtles as the *Chelydridæ*. Every relation bespeaks a ferocious form. So far as may be inferred from physiognomy it is easy to conceive this turtle with his powerful pinching and clasping beak, as preying not only on crustaceans, but even upon the larger fishes and reptiles of the Cretaceous seas.

The turtle to which this skull belonged was not more than ten feet in length, but had a remarkably broad and robust form. The flippers were short, broad, and of great power.

Measurements of the Cranium of Archelon ischyros Wieland.

(From a cotype approximately three-fifths the size of the type.)

	M.
Greatest length	·72
Width taken across the maxillo-premaxillar suture	·138
Width across middle of vomer	·145

Width through orbits	·22 ±
Height through center of narial opening	·095
Height directly back of narial opening	·17
Parietal height (greatest)	·28 ±
Width of narial opening	·07
Length of " "	·12
Greatest length of orbit	·15
" width "	·115
Length of the inferior edge of the premaxillary	·11
Length of inferior edge of the maxillary	·20
Length of inferior edge of jugal	·23
Length from extremity of beak to posterior inferior extremity of the quadrato-jugal	·58
Distance from tip of beak to antorbital border	·24
Least distance from postorbital border to the posterior border of the quadrato-jugal	·166

Measurements of the accompanying Mandible.

Greatest antero-posterior length	·465
Width across articulars	·25 ±
Antero-posterior length of symphysis	·12
Width at vertex of ramial angle	·155
Depth of symphysis at vertex of the ramial angle	·11
Extreme length of dentalium	·42
Extreme length of angular (lower outer surface)	·14

The Pelvis of Archelon ischyros.

The pelvis here described is entire, and in nearly perfect condition. As collected the parts were imbedded in an indurated marl in their natural position, with the exception of the ilia ; which were slightly inclined laterally.

The notable features of the pelvis figured here are the great width, greater than the antero-posterior length, the very broad and symmetrical ectopubic expansion, and the diminutive size of the obturator foramen, which is entirely closed by the entopubis and ischium with the consequent reduction of the interobturator cartilage from a band to a small and solid rhombic area with concave sides. These are quite the reverse of the relations seen in *Thalassochelys*. To the general outline of the pelvis of *Dermochelys* there is strong resemblance, with the important exceptions that in the latter the ilium is longer and slenderer, while the obturator foramen though much reduced in size is not enclosed.

The ectopubis increases quite regularly to its greatest thickness at the heavy anterior border. The entopubis is likewise thickest distally, that is near the median line.

The ischia are short and broad, the middle anterior portion extending inward and forward to meet the pubis.

The ilia are short and robust, and curved into distinct elbows, the dorsal angles of which are very prominent, though ligamental attachment was confined to the distinctly rounded distal ends.

There are few pelves of fossil marine turtles known with sufficient exactness to make a close comparison with the present beautiful specimen wholly satisfactory. It no doubt conforms quite nearly to the pelvis of *Protostega* which has been figured

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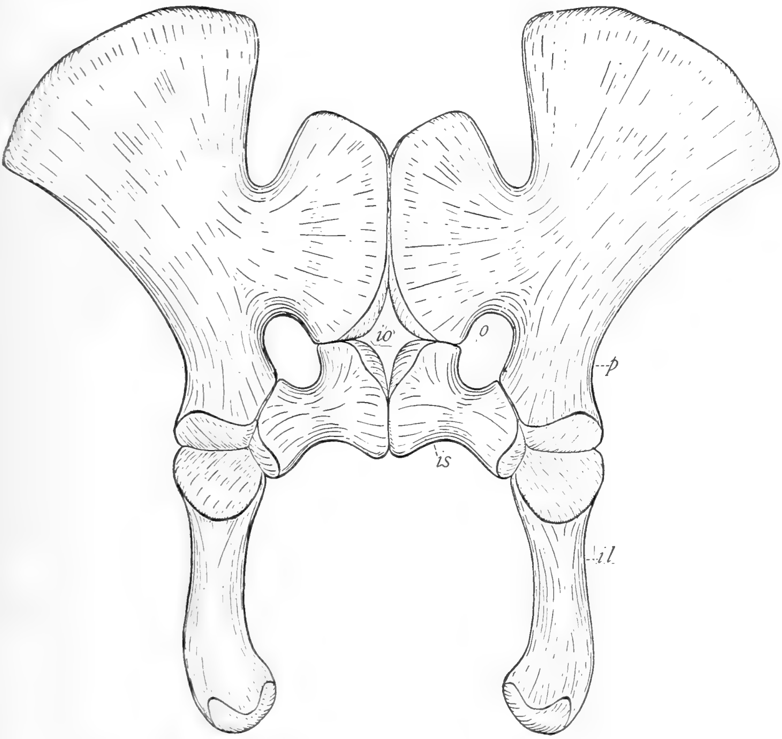

FIGURE 6. *Archelon ischyros* Wieland (type specimen). Ventral view of pelvis of specimen 12 feet in length, $\frac{1}{5}$ natural size; *p*, pubis; *il*, ileum; *is*, ischium; *o*, obturator foramen; *io*, interobturator cartilaginous area.

by Case, though the specimens he examined did not disclose the interesting conformation of the obturator foramen.

The presence of this feature, still seen in certain land turtles, in distinctly marine turtles of the Mesozoic, is certainly interesting, and may be regarded as a persistent character inherited from a land ancestry.

Measurements of the pelvis of Archelon ischyros Weiland (type).

		M.
	Extreme antero posterior length	·79
	Extreme width	·81
	Width taken across the acetabular surfaces	·46
	Shortest diameter of obturator foramen	·05
	Longest diameter of obturator foramen	·08
	Acetabular width	·12
	Acetabular length	·14
Pubis	Antero posterior length	·46
	Width, greatest	·405
	Greatest thickness (acetabular)	·175
	Antero-posterior width of entopubis	·25
	Thickness of entopubis (distal)	·07
	Thickness of ectopubis (distal)	·04
Ischium	Extreme length	·14
	" internal width	·15
	" external "	·10
	Width at middle of shaft	·06
	Thickness of " " "	·033
Ileum	Extreme length	·30
	" width of the acetabular surface	·093
	Thickness (least) at middle of shaft	·046
	Thickness (greatest) at middle of shaft	·105
	Greatest distal diameter	·095
	Least " "	·06

Archelon Marshii, sp. nov.

A second species of the genus *Archelon* is indicated by a specimen collected by the writer on the east side of the Cheyenne River in the Bad Lands proper in August 1898. Like the others, this specimen was found in the uppermost Fort Pierre Cretaceous, just beneath the Miocene or White River formation.

It consists in the plastron, humerus, ribs and a number of marginals indicating a turtle of great size, probably 11 feet in length. The humerus is rather straighter than in *A. ischyros*, and the plastron is relatively more massive, being fully one half thicker than in that species. As a slight token of respect this species is named in honor of Professor O. C. Marsh, to whose interest the Museum of Yale University is indebted for the possession of these gigantic *Testudinates.*

Position of the Genus Archelon.

While the genus *Archelon* presents many intermediate characters and strongly supports the view that *Dermochelys* belongs to the *Crpytodira*, as strenuously insisted upon by

Case in his discussion of the relationships of *Protostega* (5), its exact position may not yet be asserted positively. Bearing in mind that the turtles are an ancient highly specialized and numerous group of great constancy of form, it becomes both convenient and necessary to separate genera and families on less distinct anatomical differences than in the case of more variant orders. Moreover more exact knowledge of the fragmentary material of the Mesozoic is the first requisite; for many forms will be found like the present, disposing of old questions only to raise new ones.

In general I am however inclined to accept Cope's *Protostegidæ* (7) as containing the genera *Protostega* and *Archelon*. It is scarcely necessary to say, however, that there is a vastly greater interval between the *Dermochelyidæ* and *Protostegidæ* as thus constituted, than between the latter and the *Cheloniidæ*. I would lay especial stress upon the necessity of recognizing this general fact.

The position of *Protosphargis Veronensis* Capellini (3) is very doubtful, firstly because its skull, nuchal and fore-arm are unknown, and secondly because of the uncertainty concerning the validity of the *paraplastron*, as I have termed what I suppose represents the fused anterior plastral elements in *Protostega* and *Archelon* (15).

While the latter genera appear to be much too strongly specialized to represent more than a Cretaceous offshoot from the *Dermochelan* line of descent, *Protosphargis* may possibly be exactly in this line. The form of the plastron especially suggests such a position. The center of greatest interest has therefore in large measure shifted to *Protosphargis*. The discovery of further specimens of this genus will be of the first importance.

Attention should here be drawn to the interesting determination of the marginal series of *Protosphargis* by Capellini (4). I may mention too that a single marginal was figured in the first description of *A. ischyros* (13) which is wholly characteristic. The entire marginal series in this form is unusual in the spiny development of both the dorsal and ventral interior marginal borders, which are strongly spine-set after the manner of the plastron. Case has figured a portion of the marginal series in *Protostega* (5), but his material did not bring to light such a full development of spiniferous marginalia as is seen in *A. ischyros* and *Marshii*. That these spines represent the disappearing remnants of a normally developed carapace is a reasonable supposition and nothing more. But whether representing advancing or receding ossification the slender and untoothed marginals of *Protosphargis* indicate a sharp interval in development between these forms. The latter is undoubtedly a well marked genus.

With increasing knowledge of *Protostega* and its allies, that most interesting of questions pertaining to the *Testudinata*, the origin of *Dermochelys*, remains quite as enigmatic as ever. Hence only the following tentative classification can now be presented, the writer hoping to again attack the general subject at a future time.

Family—PROTOSTEGIDÆ Cope.

Genera—*Protostega* and *Archelon*.

{Doubtfully belonging to the *Protostegidæ*, *Protosphargis Veronensis* Capellini (3, 4), and still more doubtfully *Pseudosphargis ingens* von Könen and Dames (8).}

Synopsis of Characters of the Protostegidæ.

Marine turtles with carapace of medium curvature. Neuralia and pleuralia thin and investing the ribs but slightly. Marginalia usually spiniferous on interior borders. Plastral elements of medium development with numerous digitations. Normal epiplastron unknown, the three anterior plastral elements probably uniting into an entepi- or paraplastron. Body enveloped in a leathery hide? Skull intermediate between that of the *Dermochelyidæ* and the *Cheloniidæ*.

Genus Protostega Cope.—Squamoso-jugal union probable. Quadrato-jugal triangular. Mandibular rami coössified. Radial process of humerus strong. Carpals and tarsals unknown. Complete outline of obturator foramen unknown.—Only species *P. gigas* from the Niobrara Cretaceous of Kansas.

Genus Archelon Wieland.—Quadrato-jugal strongly united with the postfrontal, and of crescentic outline. Mandibular symphysis remaining distinct. Radial process of humerus weak, ectepicondyle strong. Carpals and tarsals undescribed. Obturator foramen small elliptical and enclosed.—Type of the genus, *A. ischyros* Wieland. Second species, *A. Marshii* Wieland. Humerus straight and robust. Plastron unusually heavy. Both species from the Upper Fort Pierre Cretaceous of South Dakota.

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ART. XXIV.—*Application of the Radio-Micrometer to the Measurement of Short Electric Waves;* by G. W. PIERCE.

KLEMENCIC* first made use of the thermal-junction as a means of measuring electric waves. His device consisted of two thin sheets of brass, *M*, 10^{cm} broad and 30^{cm} long, placed 3^{cm} apart and having soldered to them respectively a very fine platinum and a very fine platinum-nickel wire, which were crossed at *k* and were thence conveyed off at right angles and soldered at their other ends to the leads, *l*, of a sensitive galvanometer. This resonating system was fixed at the focal line of a suitable cylindric metal reflector. Electric oscillations between *M* and *M* produce heating at the knot, *k*, which gives rise to a thermo-electromotive force at the knot and consequently to a current through the galvanometer. By the use of this instrument, Klemencic has studied the reflection of electric waves from metals and sulphur, but on account of the length of his waves, he has not been able to obtain results possessed of quantitative accuracy.

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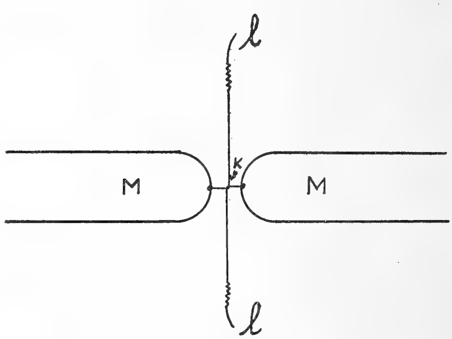

Employing a similar device of smaller dimensions, Cole† has measured the coefficients of reflection from the surfaces of water and alcohol in the two principal azimuths, and from these coefficients has calculated, by the use of Fresnel's formulas, the index of refraction and the specific inductive capacity of these substances. Also, later,‡ Cole has measured by the use of a thermal junction the absorption of electric waves by water and alcohol. P. Lebedew,§ employing a slightly different form of thermal-junction, has worked with waves of still smaller dimensions, and has obtained important results.

In the present paper, a description is given of an apparatus

* Ignaz Klemencic: Ueber die Reflexion von Strahlen electrischer Kraft. Wied. Ann., xlv, p. 62, 1892.

† A. C. Cole: Wied. Ann., lvii, p. 290, 1896.

‡ Cole: Phys. Review, vol. vii, Nov., 1898.

§ Peter Lebedew: Doppelbrechung der Strahlen electrischer Kraft. Wied. Ann., lvi, p. 1, 1895.

that I have found to be useful in quantitative experiments on electric waves.

The Resonator.—For a receiving instrument I have employed a resonating thermal-junction like that of Klemencic and Cole; but instead of a separate galvanometer, I have made the thermal system a part of the suspension in an apparatus similar in other respects to the radio-micrometer of Professor Boys. This arrangement is shown in sectional diagrams in figs. 2, 3, and 4.

Fig. 2 is a vertical section through the suspension and perpendicular to the field magnet. Upon a base, *B*, provided with leveling screws, is placed a parabolic, cylindrical reflector,

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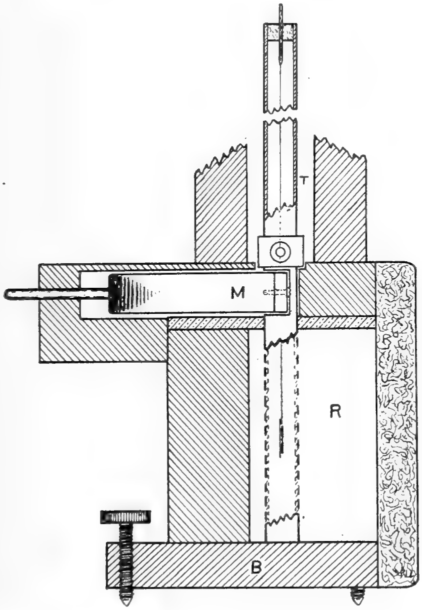

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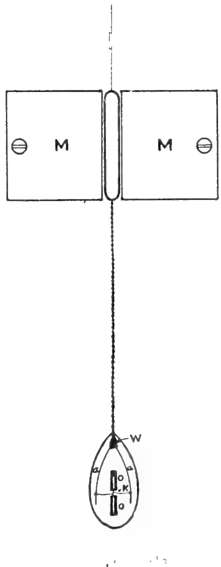
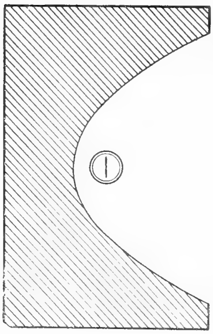


sawed from a block of wood and covered inside with a copper reflecting surface. The cavity formed by this reflector is marked *R*, and the opening of the parabola is at the right. Above the reflector and separated from it by a sheet of brass is a horse-shoe magnet, *M*, with pole pieces coming near together and projecting into the brass tube, *T*, which contains the fiber of the suspension. Within the reflecting cavity the continuation of this tube is of glass, shown by dotted lines. The parabolic reflector has a focal length of 2^{cm} and an orifice 16^{cm} wide by 13^{cm} high. The height of the pole pieces is $2{\cdot}5^{cm}$

and the distance from the bottom of the magnet to the thermal-junction is 6·7^{cm}. The pole pieces are 4^{mm} apart, and are covered with copper foil to prevent iron from getting on the coil.

A better idea of the suspension can be had from fig. 3, which is a section through the axis of the field magnet. The coil consists of a single loop, 2^{mm} wide, of number 34, *B* and *S*, silk-covered copper wire. After forming the loop, the ends of the wire are twisted together for a distance of about 5·5^{cm} downward and are then separated to form the lead-terminals *a*, *a*. The resonating system consists of two copper cylinders, *o*, *o*, 8^{mm} long, and 1^{mm} in diameter. These cylinders are about 1^{mm} apart, and to their nearer ends are soldered respectively a constantin and a manganine wire reduced by aqua regia to have a diameter of ·01 or ·02^{mm}.* These small wires are crossed at *k*, conveyed off at right angles and soldered to the leads, *a*, *a*, thus forming a closed circuit with the coil. The resonators, *o*, *o*, are sewed by silk threads to a mica vane, *v*, and the lead wires are fastened to the vane by sealing wax at *w*. The springiness of the leads keeps the finer wires in contact at *k*.

4



The clear space between the pole pieces of the field magnet is about 3^{mm}, the sides of the brass tube being cut away to admit them. The magnet, M, can be pulled back, withdrawing the pole-pieces, to allow the suspension to be lowered into the tube. When pushed forward again, it closes up snugly around the coil and prevents air currents from coming into the cavity in which is the suspension.

When electric waves of proper length enter the cavity, R, they are converged by the reflector and cause electric surgings up and down between the cylinders *o*, *o*, heating the thermal junction *k* and producing a steady current through the coil. Being in a strong magnetic field, the coil turns so that its plane makes a small angle with the axis of the magnet. These small deflections are read by an Elliott reading telescope of such good definition that tenths of a millimeter can be estimated with considerable accuracy.

The thermal-junction must be carefully protected from radiant heat. To effect this the magnet, the back of the reflector, and the suspension tube are covered by wood 3^{cm} thick; the opening of the reflector is closed by a sheet of

* For an explanation of the method of making these small wires, see Lebedew's paper, l. c.

cotton wool of about the same thickness; and the whole instrument is then put under a pile of felt 5 or 6^{cm} thick. The only part that is at all exposed is the mirror of the suspension, which is viewed through a double glass window, and is further protected by screens from lamps in the room and from the body of the observer.

The suspension is hung by a fine quartz fiber, of which the force of torsion serves as control. The weight of the system is ·27 gram, of which the mirror weighs ·05, and the resonating cylinders ·144 gram. The period of a swing one way is 3 seconds. The resistance of the thermal-junction is about 2 ohms.

It might be supposed that the sensitiveness of the instrument could be increased by making the coil of about 30 turns, which would give it a resistance equal to that of the thermal-junction. I have found, however, that the control by the field, due to the magnetic properties of the copper, is so great as to give a smaller sensitiveness with a large number of turns than with a single loop. This instrument, because of the resistance of the thermal-juuction, cannot be made to have the extreme delicacy of Mr. Boys's original radio-micrometer.* It has, on the other hand, a sensitiveness that is not easily obtainable by the use of a thermal-junction with a low resistance galvanometer, as is shown by the following rough test:

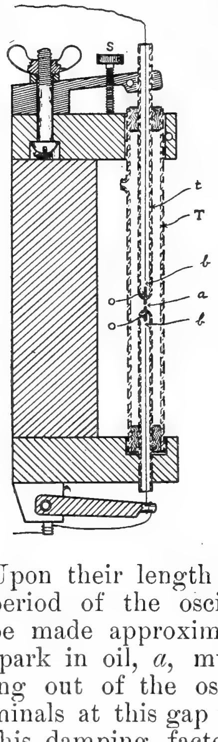
A thermal couple of German silver and manganine wires of commercial size, when connected to a galvanometer with a figure of merit of 10^{-8}, gave a deflection of 2^{cm} when heat was focussed upon it from a distant lamp. The instrument described above with approximately the same heat, less the amount absorbed by the glass tube, gave a deflection of 40^{cm}; to obtain which the German-silver-manganine couple would have required a galvanometer capable of giving a deflection of 1^{mm}, at a scale distance of 100^{cm}, for a current of 5×10^{-10} amperes.

Another advantage of the D'Arsonval arrangement is that it can practically be made dead-beat and is unaffected by outside magnetic disturbances. This is important in the measurement of electric waves, since, on account of the variable nature of the source of the waves, throws instead of permanent deflections must be read; and to get consistent throws it is necessary to have the suspended system start from a state of rest, a condition difficult to attain with a sensitive galvanometer even when shielded. The instrument described above has kept its zero within a very small range for over a month, and after a reading is taken comes rapidly to rest, disturbed only by the slight tremors of the pier on which it is placed.

*C. V. Boys: Phil. Trans., vol. clxxx, A, p. 159, 1888–1889.

However, when the instrument was set up, it was at first violently influenced by an electrostatic action coming direct from the oscillator. This proved to be due to a small condenser that had been placed in series with the secondary of the induction coil for the purpose of diminishing the arc at the oscillator. By removing this capacity, and by coating over with tin foil the wooden cover of the top part of the receiving apparatus, a recurrence of this disturbance has been prevented.

5



The Oscillator.—Reference is made to fig. 5. Two platinum cylinders, *O*, tipped with pieces of iridium, are fused into the ends of small tubes of thermometer glass, *t*. These thermometer tubes are passed through the rubber stoppers of a larger tube, T, for holding oil. The larger tube has a diameter of 2^{cm}, and by wooden braces is held at the axis of a parabolic cylindrical reflector of the same dimensions as that of the resonator. The distance between the platinum cylinders of the oscillator can be adjusted by means of the micrometer screw, *s*. Into the smaller tubes are brought two small platinum wires connected by copper leads to the secondary of an induction coil of medium size. These wires are separated by spark-gaps, *b*, from the platinum cylinders.

The spark-gaps, *b*, are about 2^{mm} long, and serve to isolate the platinum cylinders. Upon their length seems to depend in a slight degree the period of the oscillation, which by their adjustment can be made approximately equal to that of the resonator. The spark in oil, *a*, must be very short to prevent the damping out of the oscillations. The wearing away of the terminals at this gap is a source of great annoyance by changing this damping factor, and consequently changing the quantity of energy radiated as electric waves. Platinum is the only metal that I could fuse into the glass tubes that would not break the tubes under the heat of the spark, and platinum was found to wear away very rapidly, presumably on account of the action on it of the hydrogen freed by the decomposition of the oil. I have attempted to diminish this destruction of the oscillators by tipping them with pieces of iridium fused on with copper as a solder. The iridium disappears much more slowly than the bare platinum. Other oscillators I have tipped with silver, but the iridium serves better. However,

since only one of the terminals wears away, a pair consisting of one with a silver tip and one with an iridium tip is about as good as two of iridium. Also, the decomposition of the oil deposits carbon on the terminals, changing the oscillations by temporary short-circuits, making the readings irregular. I have not attempted to avoid this except by frequent renewal of the oil. It might perhaps better be done by forcing a continuous jet of oil across the spark. As a liquid dielectric for the spark, *a*, I have used vaseline oil; in this following the example of Mr. Righi.

The Break of the Induction Coil.—To get a strong, constant source of the waves, it is important to have an interrupter for the primary circuit of the induction coil that is rapid and uniform. To this end I have employed a motor-break of the Foucault type. A platinum rod, attached directly by an eccentric to the shaft of an alternating-current motor, is plunged up and down in a cup of mercury. The motor is of the type supplied by the General Electric Company to run their small portable fans, and makes about 1,500 revolutions per minute. The surface of the mercury is kept clean by a stream of water that flows continually over it—a device previously employed by Mr. Maclean* in this laboratory. In spite of these precautions I have not been able to obtain a constant source of waves; the oscillator slowly deteriorates, and the readings of the instrument get gradually smaller. This source of error is, however, quite regular, and in most of the work of comparing quantities can be fairly well eliminated by taking alternate readings and averaging.

For good adjustment of the oil spark-gap a deflection of 8^{cm} can be obtained with the oscillator at 50^{cm} from the resonator. For better regularity of the measurements, the spark was ordinarily adjusted so as to give between 1 and 3^{cm} deflections.

Quantitativeness of the readings.—At the outset the question arises as to what relation exists between the deflections of the instrument and the intensity of the radiations that produce them. We should suppose beforehand that these two quantities are directly proportional, for the deflections are proportional to the electromotive force at the thermal knot. This e.m.f. should be very approximately proportional to the heat developed there, which being of the dimensions of energy should be proportional to the intensity of the waves.

Attempt to test this point by depriving the oscillator of its parabolic reflector and measuring the deflections produced in the resonator at various distances from the oscillator presents difficulty; for, in the first place, if we start with the conclusions of Hertz's mathematical theory of the oscillator that the

* G. V. Maclean, this Journal, vol. viii, July, 1899.

intensity at a point is inversely as the square of the distance from the source, we obtain from a linear source and a parabolic receiving reflector an integral that is difficult to treat. In the second place, we cannot eliminate the difficulties arising from diffraction.

I have attempted in another way to get experimental evidence of the significance of the deflections of the receiving instrument. With the oscillator and the resonator both armed with their parabolic reflectors, the effect was measured of turning the oscillator to an angle, α, with the resonator about the common optical axis of the two reflectors. The oscillator was directly in front of the resonator at a distance of 52^{cm}, and the angle of turning was read off in degrees on the scale at the back of the reflector of the former. The headings of the respective columns are the angles of turning. In the columns are the corresponding deflections of the receiving instrument in millimeters. Alternate readings were taken.

0°	30°	0°	45°	0°	60°	0°	90°
12·2	9·8	12·4	6·9	11·2	4·2	10·4	1·5
11·9	10·1	12·2	6·4	11·6	4·2	9·5	1·1
11·0	9·4	12·0	6·6	12·5	3·9		1·2
11·6	8·9	11·9	6·6	11·3	3·7		
11·0	8·7	11·6		10·6	4·2		
10·5	8·5						
10·6	8·5						
10·3							
11·14	9·13	12·0	6·62	11·4	4·04	10·0	1·3
Ratio	·819		·552		·355		·13
Other values obtained for the last ratio							·16
							·17
Averaging							·15

Now if the wave is plane-polarized and we neglect the effect of the second metallic reflection on the nature of the polarization, we should have for the component of the intensity in the direction of the resonator the formula

$$I_1/I_2 = \cos^2 \alpha.$$

But when the instruments were at right angles there was a small deflection remaining which was not accounted for by this formula. This was shown to be due to the waves, for a metallic screen interposed nullified it completely. Whether this effect is due to a mixed polarization of the waves or due to the action of the waves on the short, fine wires perpendicular to the resonating cylinders in the thermal-junction, it shows a component of

intensity at right angles to that accounted for in the above formula, and suggests the addition of a term $\cdot 15\sin^2 a$.

If this is done we have

$$I_1/I_2 = \cos^2 a + \cdot 15\sin^2 a.$$

With this formula, I have calculated the ratio of the intensities and placed them in the third column of the following table for comparison with the ratio of the deflections:

a.	d_1/d_2 obs.	I_1/I_2 calc.
0	1·	1·
30	·819	·79
45	·552	·575
60	·355	·362
90	·15	·15

It is seen that the observed values agree fairly well with those calculated from the formula. Though the experiment is not conclusive, it seems strongly probably that the deflections of the receiving instrument are proportional to the intensity of the waves.

The wave-length in this and the next experiment was $4\cdot 4^{cm}$, measured by the method of stationary waves.

Transparency of Wood.—Mr. Righi has shown that certain woods transmit waves more freely when the grain is in one direction with respect to the oscillator than when it is in the perpendicular direction. Below is a short table of data confirming Mr. Righi's observation. A piece of pine board 22·4 centimeters square by 4·8 centimeters thick was interposed between the oscillator and the resonator, and readings were taken with the grain perpendicular to the direction of the electric oscillation, with the grain parallel to these oscillations, and then with the board removed. The readings are in millimeters, and the *dashes* indicate the order of taking the observations.

Out.		Grain perp.		Grain parallel.	
		13·4	——	8·0	——
15·4	——	12·8		7·9	
15·8		12·2		7·0	
17·1		12·2		7·0	
15·0		12·0		6·5	
14.5		10·5		6·9	
14·2		10·0		7·1	
14·2					
15·2		11·9		7·2 means.	

Percentage transmitted with the grain perp. is 78·3.
" " " " par. is 47·4.

The transparency of this board with the grain parallel to the electric oscillation is about 60 per cent of its transparency with the grain perpendicular. Another set of measurements gave for this quantity the value 59·2. For these two orientations, white oak and white wood show very small differences respectively in their transparencies. The striking characteristic of pine in this respect is undoubtedly due to difference between its electric conductivity in and across the grain.

A grating formed of strips of metal 2^{cm} wide and 2^{cm} apart was found to transmit 96% of the incident waves when the strips were across the oscillator, and 29% when the strips were parallel thereto.

A single rod of brass 3/16 inch in diameter, placed between the oscillator and the resonator parallel to the electric displacement, was found to screen off 40% of the waves.

These simple experiments are intended merely to show the adaptability of the apparatus to quantitative work with electric waves. Other investigations are in progress.

Jefferson Physical Laboratory,
Harvard University.

ART. XXV.—*Some remarks on the latest publications of Fl. Ameghino;* by SANTIAGO ROTH (Museo de la Plata).

IN the "Segundo Censo Nacional de la Republica Argentina," 1898, i, p. 111–125, Fl. Ameghino published a paper entitled: "Sinopsis Geologica-Palaeontologica," in which he gives a systematic account of the fossil-bearing deposits of Argentina. His divisions and correlations of the different horizons are so positive, that any one, who is not well acquainted with the geology of the Argentine Republic, must believe that they are well supported.

In July of the same year he published a supplement to this paper,* in which the sedimentary and eruptive formations between Bahia Blanca and the Cordilleras described by myself† have been inserted into his system.

In regard to the latter point I should like to express briefly my own views, which differ from those of Ameghino, since I fear that the latter may be accepted as well founded—as has happened in other cases—when I have left them unnoticed. For instance, I described the new species of *Toxodon elongatus*, which Mercerat has declared to be identical with *Toxodon giganteus*. The latter is founded upon a femur from Monte Hermoso, which, as may be seen at a glance, does not belong at all to the genus *Toxodon*. It was at first my intention to make no reply to this, but I have seen, much to my regret, that this failure on my part has induced Dr. Trouessart in his "Catalogus Mammalium" to give *Tox. elongatus* as a synonym of *Tox. giganteus*, and to let *Dilobodon* stand as a good genus. Trouessart, of course, could only follow the literature, since he did not possess any material for comparison, and the same reason explains numerous other errors in the "Catalogus" in respect to the Argentine fauna. Trouessart has taken all the doubtful facts given by Ameghino in good faith, although a part of them have been altered meanwhile by Ameghino himself.

Whoever has taken pains to compare Ameghino's dates in his different papers must surely be struck with the idea that they cannot be taken seriously, since he frequently changes his opinions, and abandons views he propounded very positively at first. Thus in 1889‡ he placed the Patagonian beds above the Santacruzian, Paranense and Mesopotamian, and called them Oligocene; in 1894§ he says, that the Santacruzian formation

* Sinopsis Geologica-Paleontologica, Suplemento (Adiciones y Correcciones) Julio, 1899, La Plata.

† Apuntas sobre la Geologia y Paleontologia de los Territorios Rio Negro y Neuquen. Anal. Mus. La Plata, 1898.

‡ Mamiferos fosiles de la Republica Argentina.

§ Enumeracion synoptique des espèces des Mammifères fossiles des formations éocènes de Patagonie. Buenos Aires, 1894.

lies above the classical Patagonian, and that the latter belongs partly to the Lower Eocene, partly to the Cretaceous. The Tehuelche formation has suffered a change still more incomprehensible; in 1889 (l. c.) we find it on top of the Pampean formation, which is, according to him, Pliocene, and consists of the stages: Ensenadense (Pamp. inf.), Belgranense (Pamp. med.), Bonaerense (Pamp. sup.) and Lujanense (Pamp. lacustre); the Tehuelche ought to be, accordingly, Quarternary, which is the opinion of others. But in his latest paper* he puts it in the Lower Miocene!

Ameghino has never seen any Patagonian deposits with his own eyes, and bases his divisions and theories, which he propounds in every case as well proved facts, upon the reports of other investigators, chiefly upon the alleged observations of his brother Carlos. There is no doubt that his present division will meet the same fate as all the rest: indeed, it will be shown that it is even less tenable than those given previously by him; and it is very significant, that he *begins already* new changes immediately after the conclusion of his latest paper.

As to the correlations of the formations investigated by myself in the territories of Rio Negro and Neuquen with this absurd division, I wish to make the following statements.

1. In the "Suplemento" he says: "*Piso Pyrotheriense.* Mr. Roth has observed very extensively the beds of this stage, which he designates as "Toba (tufa) cretacea," in the territories of Chubut and Santa Cruz, and has found in them, at different localities, bones of Saurians and Mammals." The fact is, that I have never been farther south than the Rio Deseado, and that I have never found, in these Cretaceous tufas, any remains of the Pyrotherium fauna described by Ameghino, but of a fauna entirely different from it. On my last voyage, however, I found representatives of a great number of genera and species belonging to his Pyrotherium fauna in deposits of a loess-like character and of much younger age, but so far no traces of the genus *Pyrotherium* itself. I have long doubted that the genus *Pyrotherium* is represented in the same beds with the other genera of this fauna, and the same doubt has been expresssd by Mr. Hatcher, who has traveled several years in Southern Patagonia, and has made extensive collections. And, indeed, Ameghino, after having met Mr. Hatcher, changes his former ideas as to the Pyrotherium fauna. In the conclusion of his supplement (l. c., p. 13) he says in a supplementary note: "According to information sent to me by Carlos Ameghino regarding the explorations made during his last voyage from Puerto Deseado, it has now been settled that what we have called the Pyrotherium fauna consists really of

* Segundo Censo, etc.

two very different faunas, which have been mixed up by him, because the beds in which the remains were found, have been met with in such a position that there seemed to be no break between them. Now he has found them separated in certain localities, and lying unconformably to each other, and it is possible to recognize two faunas separated by a considerable geological interval. The true Pyrotherium fauna, which may be known henceforth by this name, is the younger and belongs to the Upper Cretaceous, while the older, in which *Pyrotherium* is wanting and which has been called by Carlos the Notostylops fauna, belongs to the Middle Cretaceous."

This new version does not agree with my observations, and it will finally be shown that *Pyrotherium* is not at all associated with these mammalian remains. The other genera, which he designates as belonging to the "Pyrotherium fauna" are positively *not* from those Cretaceous beds, which contain the remains of Mesozoic Saurians, but belong to Tertiary deposits, and have nothing to do with the Mesozoic mammals described by myself.

In all the papers in which Ameghino treats of this fauna, he states that remains of rodents are frequently found associated with it. Among the mammalian remains discovered by myself I was struck by the complete absence of rodents. Although I have found this fauna again on my last trip in various localities, I did not find in it remains of a single rodent. Of course, this does not prove that rodents are entirely wanting in this fauna, but since in other Mesozoic deposits no rodents have been discovered, it seems very probable that also in Patagonia this group did not make its appearance before Tertiary times.

2. I cannot understand what Ameghino means by his "Piso Sehuense," which, with the Piso Pehuenche and Pyrotheriense is said to constitute his Guaranitic formation. He associates in this stage all possible deposits which are mentioned also in other stages: for instance, he says, that a tufa-deposit belongs here, in which I have found associated with mammalian remains a skull of a species of *Megalosaurus*. The mammalian remains, he alleges, belong to the Pyrotherium fauna, that is to say, to the Piso Pyrotheriense, but the skull of *Megalosaurus* to the Piso Sehuense! For this skull he creates a new genus, *Longosaurus argentinus*, although he has never seen it, and says that a piece of a femur found by his brother near Rio Sehuen belongs to the same species. (The skull has been sent to London for determination.)

Further, he puts into this stage the marine deposit discovered by me near Roca on the Rio Negro, and says that the same is found well developed on the Limay and Pichpicuru Leufu, as well as on the Collon Cura. I have traveled in the country

near the Limay four times, and have never seen a trace of marine deposits, and the same results have been obtained by Drs. Moreno, Wehrli, Zabalowicz, Siemiradzki and others. On the Pichipicuru Leufu, Mr. Hauthal has met with marine deposits in the upper part; these, however, belong to the Lower Cretaceous and have nothing in common with those from Roca. On the Rio Collon Cura itself there are—as far as it has been explored—no marine deposits; but such deposits are present in what is called Angostura, several hours distant from the river. These, however, are of Jurassic age (Lias). These two marine deposits are no doubt much older than those near Roca, and it is impossible that they belong to one and the same stage. Upon what grounds Ameghino places the marine beds of Roca in his Piso Sehuense, does not appear in his paper.

3. Regarding the Tertiary tufa-deposits on the Collon Cura discovered by me, he says that they belong to the Patagonian formation. As to the latter, so much confusion prevails, that a more extended discussion, than is now possible, would be necessary to determine the validity of this correlation. It is sufficient to remark, that the tufas in question are of the same age as the marine beds on the coast near the mouth of the Rio Chubut, and that in both the same mammalian remains are found as in the Santacruzian. Ameghino bases his opinion, that the tufas of Collon Cura are older than the Santa-Cruz-beds, on the fact that remains of *Propachyrucos* and *Eutrachytheres* are present in them, which he regards as characteristic Cretaceous mammals. *Eutrachytheres*, however, or at least a very closely allied genus of the family *Typotheridæ*, is found in Patagonia in very much younger deposits, from which we have secured several species of the genus *Toxodon* and a species of *Megatherium*. *Propachyrucos* is so closely allied to *Pachyrucos*, found abundantly in the lower Pampean beds, that its presence in the Santacruzian is not at all strange. The very presence of these two genera, so highly specialized, in the so-called Pyrotherium fauna, is an argument for the young age of the latter, and if it were not for some more primitive forms associated with them, we could agree with Mr. Hatcher's opinion, that the Pyrotherium fauna is younger than the Santacruzian. But, as is shown by stratigraphical evidence, it is really older than the latter.

4. The sandstone-formation of the Rio Negro, which has been described carefully by Zapalowicz* and myself,† is placed by Ameghino in the Piso Rionegrense, which he believes to be Lower Miocene. Apparently his reason for this is, that he confuses the sandstone formation with the marine deposits, which are exposed in some places near Carmen de Patagones.

* Das Rio Negro Gebiet in Patagonien. Denkschr. k. Akad. Wiss. Wien, 1893.
† Apuntes sobra la Geologia, etc., 1898.

All the molluscs which he quotes from the Piso Rionegrense are found in the marine deposits of Chubut, which follow the coast up to the mouth of the Rio Negro, and which are much older than the Rio Negro sandstones.

This sandstone deposit has a very wide distribution in Patagonia, and extends as far west as the Cordilleras. I have found it in all cases immediately below the glacial bowlder formation, and it belongs no doubt in the uppermost Tertiary, and corresponds possibly with the Cape Fairweather beds of Hatcher.

5. The same seems to be true of the Piso Tehuelchense, which Ameghino puts also in the Lower Miocene. The marine deposits, however, which he refers to as belonging here, seem to be older.

Ameghino apparently has not the slightest idea of the stratigraphy of Patagonia, otherwise such confusion would have been impossible, and he would not have published the erroneous view that the Tehuelche formation, in which he includes the Patagonian bowlder formation, which is clearly Quaternary, belongs in the Lower Miocene!

I cannot enter upon a detailed discussion of the palaeontological part of his Sinopsis: the same confusion prevails here as in the geological part. He retains all the genera and species created by himself, many of which cannot stand in the face of a candid criticism; on the other hand, he declares many of those genera created by others to be synonyms of his own. For instance, without giving any proof he makes all the new species determined by me from the Tertiary deposits on the Collon Cura* synonyms of species described by himself from the Santa-Cruz beds, and he does the same thing with my Mesozoic mammals,† declaring all genera without exception to be identical with genera of his Pyrotherium fauna. Mr. Hatcher, who looked over some of the types of this latter fauna with Ameghino, when he was shown the Mesozoic mammalian remains of our collection, remarked that he had seen nothing like this fauna either in Ameghino's collection or during his travels in Patagonia, and that nothing of the kind was known to him from North America. Since Ameghino does not mention any facts supporting his allegations, there is no reason why I should cancel a single one of my genera, or why I should characterize them again. But in order to show how arbitrarily he acts, I reproduce here the figures of two species of Mesozoic mammals described by myself, and the figures of his species with which he says they are identical. I may mention also, that in several cases he declares a genus of which I possess only the upper jaw, to be identical with a genus of which he has only the lower, or vice versa.

* Apuntes, etc., 1898.

† Aviso preliminar sobre mamiferos mesozoicos, Rev. Mus. La Plata, 1898.

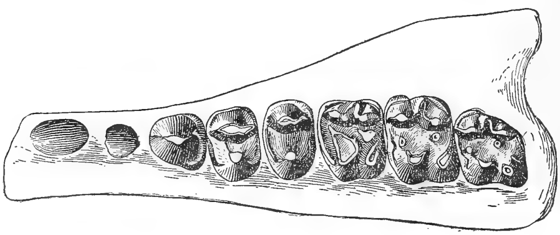
In the "Suplemento," p. 12, he says:

"*Polyacrodon ligatus* Roth p. 384, corresponds with *Didolodus multicuspis* Ameghino, 1897.

Megalacrodon prolixus Roth p. 384, corresponds with *Polyacrodon lanciformis*, Roth p. 383, and *Lamdaconus suinus*, Amegh. 1897."

I now beg to compare Fig. 1, which represents *Didolodus multicuspis*, with Fig. 2, which represents the upper molar, on which my *Polyacrodon ligatus* is founded. While the latter with its very low crown in the form of cones reminds one very much of the Marsupials, the former shows the cones in *Didolodus* already as characteristic features of the Ungulates.

1



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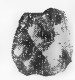

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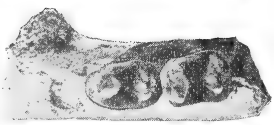
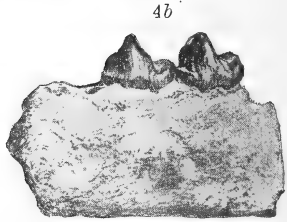


4*b*



Nevertheless they are said by Ameghino to belong not only to the same genus, but to the same species.

In Fig. 3 I have reproduced *Lamdaconus suinus*, and in Fig. 4*a* and *b* *Megalacrodon prolixus*. The molars of the latter show an astonishing likeness to those of *Didelphys*, while the tooth of *Lamdaconus* exhibits clearly the shape of the Patagonian type of Ungulates. These two animals cannot even belong in the same family.

Any further discussion seems to be unnecessary.

ART. XXVI.—*On a large slab of Uintacrinus from Kansas;* by C. E. BEECHER. With Plates III and IV.

A LARGE slab of limestone preserving on its surface numerous specimens of *Uintacrinus socialis* Grinnell has recently been placed in the exhibition series of the Yale University Museum. This slab is of especial interest on account of its size and for the perfection of the crinoids represented. Bather* has so ably described this species that nothing of consequence can be added regarding the details of structure and probable habits. The present notice, therefore, will necessarily be restricted to minor features.

The first specimens of *Uintacrinus* were collected by Professor Marsh in 1870, from the Cretaceous of the Uintah Mountains, Utah. Later, in 1876, better examples were obtained in western Kansas by Dr. S. W. Williston and by Professor B. F. Mudge for the Yale Museum, which now contains collections of this crinoid from Trego, Gore, Logan, and Wallace Counties, Kansas. Notwithstanding this considerable geographic range, the horizon appears to be nearly constant at about the middle of the Niobrara Chalk.

The specimens are uniformly on the underside of thin lenticular plates of a limestone that in itself is an encrinital rock composed of dissociated crinoid elements. The lenses of limestone seldom have a maximum thickness of an inch. Usually the calyces of *Uintacrinus* are almost completely flattened, but occasionally, as in the slab here described, they stand out in considerable relief, though in none is the normal fullness preserved.

The slab represented on Plate III measures six feet, seven inches, in length (2 meters) by four feet, six and one-half inches in breadth (1^{m} 38^{cm}) and, after making allowance for irregularities in outline, it contains about twenty-seven square feet of surface ($25{,}800^{sq\ cm}$). In this area are the calyces of two hundred and twenty individuals of *Uintacrinus socialis.* The diameter of a calyx of average size, in a somewhat flattened condition, is about 60^{mm}. Occasionally a specimen measures 70^{mm} across, and apparently this is nearly the maximum size attained by the species. The smallest specimens are not more than 20^{mm} in diameter. The arm-branches can seldom be traced more than 10^{cm} from the calyx, though separate ones extend at least five times this distance over the surface.

* On Uintacrinus: a Morphological Study. By F. A. Bather, M.A. Proceedings of the Zoological Society of London, vol. 1895, pp. 974–1004, pls. liv–lvi, 1896.

Most of the specimens are lying on the side with the arms extended ventrally in a plumose manner. A considerable number, however, present the basal aspect of the calyx, and in this position the arm-branches belonging to a particular individual can rarely be observed, since they seem to penetrate below the surface of the slab and lie in another plane. It will be seen that the calyces lying on their sides point in all directions in the plane of the slab, though a considerable number have their arm-branches extended toward the upper edge of the slab as it now stands. This could indicate at the most but an extremely gentle current, and the presence of several small oysters (*Ostrea larva* Lam.) tends to show that the water was of moderate depth.

Two slightly diverging grooves in the surface of the slab at the right, below the middle, suggest the mold of an object like a Baculite, but as no vestige of shell is preserved, it may be an accidental feature.

Nearly all the specimens of *Uintacrinus*, as well as the limestone layer containing them, are of a light buff color, while the slight coating of shaly matter is also light in hue, sometimes of a bluish tint, so that the contrast between the fossils and the matrix is not strongly marked. This defect has been obviated by painting the entire slab with a mixture of gum-water and ivory black, which penetrated and adhered to the shaly and weathered surface of the limestone, but was easily washed from the calyces and arm-branches of the crinoids. This treatment has rendered the slab an object of great beauty, with its medusæ-form crinoids and the delicate tracery of the arm-branches against the dark background.

Yale University Museum, New Haven, Conn., February 10, 1900.

EXPLANATION OF PLATES.

PLATE III.—Slab of *Uintacrinus socialis* Grinnell, containing two hundred and twenty individuals. Size 6 ft. 7 in. (2^m) by 4 ft. 6½ in. (1^m 38^{cm}). Niobrara Chalk. Near Elkader, Logan County, Kansas. Presented to Yale University Museum by Professor O. C. Marsh. Collected by H. T. Martin.

PLATE IV.—A portion of the same slab on a larger scale.

ART. XXVII.—*Granodiorite and other intermediate rocks;* by WALDEMAR LINDGREN.

Introduction.—Along the great mountain chain which follows the Pacific Coast of America from Cape Horn to Alaska the intrusive rocks and the phenomena accompanying them are displayed upon a scale hardly rivaled elsewhere. Moreover, these intrusions have taken place in comparatively recent times, during Jurassic, Cretaceous and even Tertiary times. The result was the formation or the accentuation of the great ranges now overlooking the Pacific Ocean. The uplift which accompanied the displacing intrusion of enormous masses of magma, was followed by a period of erosion of scarcely appreciated magnitude. This erosion brought to light the deeply buried, intruded granular rocks as great, irregular bodies, *batholiths*, sometimes continuous for hundreds of miles. Before these remarkable relations had been elucidated, the granular rocks of the Pacific Coast were often regarded as Archean; and a close scrutiny of supposedly older areas brings almost yearly additions to the Mesozoic and Tertiary batholiths.

Looking over the results thus far obtained by investigations of these rocks, one cannot fail to note the prevalence of rocks occupying intermediate places between granite and quartz-diorite. The latter are fairly common; the true granites are relatively rare; most common appears an intermediate rock in which the soda-lime feldspars predominate over the orthoclase, and in which the silica varies from 60 to 70 per cent.

Granodiorite, origin of name.—Soon after the beginning of the geological mapping of the Sierra Nevada in California in 1886, it became apparent that the rocks of that region which had previously been referred to as granite were, to a large extent, of intermediate character and could properly be referred neither to the granites, nor to the quartz-diorites. Besides these intermediate rocks, quartz-diorites, diorites, and gabbros were recognized. The prevailing intermediate rock from different parts of the Sierra Nevada was studied by the geologists then working there (G. F. Becker, H. W. Turner, and W. Lindgren) and was found to have a fairly constant character, consisting of a medium to coarse-grained aggregate of quartz, oligoclase or andesine, orthoclase, biotite, hornblende and various accessory constituents, among which titanite was most prominent.

A series of separations by the Thoulet solution were made by the writer of rocks from various points of the Sierra Nevada, partly from the foothills, partly from the Yosemite Valley, and partly from the eastern slope of the Sierra, in the State of

Nevada. The series also included a variety carrying large orthoclase crystals, and extensively developed in Tuolumne County. The result showed that all these rocks were characterized by about the same amount of quartz and that in all of them the soda-lime feldspar (andesine or oligoclase) greatly predominated over the alkali feldspars, both always being present.

A great number of slides had been examined, but at that time (in 1891) the analytical data were less complete than might have been desired. The first analysis considered as representing the composition of granodiorite was the one published by Mr. Clarence King in the volumes of the "Exploration of the 40th Parallel," the locality being El Capitan. Yosemite Valley. This analysis runs as follows:

SiO_2	66·40
Al_2O_3	17·13
FeO	3·77
MnO	·30
CaO	4·05
MgO	·97
K_2O	2·08
Na_2O	4·49
Ignition	1·03
	100·22

For the rock described above the name of *granodiorite* was proposed, the term being suggested by Mr. G. F. Becker. The name was intended to cover intermediate acid rocks which were more closely related to a quartz-diorite than to a granite, but was not proposed as a synonym for quartz-mica-diorite.

Further definitions.—In the text to the older folios of the gold belt the term granodiorite is defined as follows (Sacramento Folio, No. 5, 1894): It should be remembered that these brief descriptions are chiefly intended for the non-technical reader.

"*Granodiorite* (quartz-mica-diorite).—A granular intrusive rock having the habitus of granite and carrying feldspar, quartz, biotite, and hornblende. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspars. This granitic rock might be called quartz-mica-diorite, but this term, besides being awkward, does not sufficiently suggest its close relationship with granite; it has, therefore, been decided to name it *granodiorite.*

In the later folios (Truckee No. 39, 1897) the definition is slightly altered in form and reads as follows:

"*Granodiorite.*—A granular intrusive rock having the habitus of granite and carrying feldspar, quartz, biotite and

hornblende. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspar. This granitoid rock occupies a position intermediate between a granite and a quartz-diorite, and is in fact closely related to the latter. The large areas occupied by it and the constancy of the type justify the special name."

In 1893 I attempted to limit the rocks from a chemical point of view.* On account of the few analyses available this first attempt could not be as precise as the later definitions, but requires only slight correction. The statement is as follows: "A light gray granitic rock occupies the larger part of the area of the map . . . The rock is in general identical with the gray so-called granite that occupies such large areas in the Sierra Nevada and which probably extends through Southern California far down into the peninsula of Lower California. The rock consists in typical development of feldspar, quartz, biotite and hornblende with medium-grained, hypidiomorphic structure. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspars. The silica varies between 60 and 73 per cent; the amount of lime is variable but it rarely exceeds, while it usually falls somewhat short of, the sum of the alkalies. While in some varieties that cannot be distinguished from the others in the field there is more potash than soda, a frequently occurring relation is 2 per cent K_2O to 4 per cent Na_2O. It will be seen that the rock very closely approaches some quartz-mica-diorites and often might be indicated by that name. This term, however, besides being clumsy does not sufficiently express its close relationship to granite, brought out by its frequently high percentage of silica and low percentage of lime, by its variable percentage of alkali feldspar, and by the muscovite sometimes occurring in it."

The last part of this sentence refers to a facies from Rocklin, Placer County and other places which probably should not be included in the granodiorites.

In a report on the veins of Grass Valley and Nevada City, Cal.,† the following definition is given:

"Under the name *granodiorite* are included coarsely granular rocks, intruded and consolidated at considerable depths below the surface, having a normal granitic (eu-granitic) structure, and a mineralogical composition of quartz, soda-lime feldspars, orthoclase, hornblende, and nearly always biotite. Titanite and magnetite are always present as accessory constituents. This rock, which in the Sierra Nevada occurs in enormous areas, forms an intermediate group between the quartz-mica-diorites and the granites, being, however, more

* This Journal, lxvi, 201. The Auriferous Veins of Meadow Lake, Cal.

† 17th Ann. Rept., 1896, U. S. G. S., Part II, p. 35.

closely allied to the quartz-mica-diorite than to the granite. Comparison of numerous analyses from various parts of the Sierra Nevada shows that the chemical composition varies between that of a quartz-mica-diorite and a quartz-monzonite (adamellite, banatite, Brögger). Its geological occurrence and in general entirely similar habit preclude the possibility of dividing it into subgroups.

The rock is very characteristic and cannot easily be mistaken. The feldspars are generally white; the quartz is not very conspicuous and does not occur in large grains, as in some true granites of the High Sierra; the hornblende is dark-green, often in long, rough prisms; the biotite is of the usual dark-brown color. The general effect is a light-grayish color."

The following table is also quoted from the same place:

LIMITS OF VARIATION AND AVERAGE COMPOSITION OF GRANODIORITE.

	Limits of variation. Per cent.	Average composition. Per cent.
SiO_2	59 to $68\frac{1}{2}$	65·
Al_2O_3	14 to 17	16·
Fe_2O_3	$1\frac{1}{2}$ to $2\frac{1}{4}$	1·50
FeO	$1\frac{1}{2}$ to $4\frac{1}{2}$	3·
CaO	3 to $6\frac{1}{2}$	5·
MgO	1 to $2\frac{1}{2}$	2·
K_2O	1 to $3\frac{1}{2}$	2·25
Na_2O	$2\frac{1}{2}$ to $4\frac{1}{2}$	3·50
Remainder	------	1·75
		100·

In 1897* in a paper on the granitic rocks of the Pyramid Peak Folio, I characterized the granodiorite of the High Sierra as follows: Comparing the analytical and microscopical results with the field notes, it is clear that the granodiorite, as it appears in the High Sierra, is a rock of well-defined and fairly constant composition, structure and appearance. It is neither a normal diorite, nor is it a granite; it is clearly an *intermediate* type, occupying a place between normal quartz-mica-diorite and quartz-monzonite (Brögger).† All transitions toward

* This Journal, vol. iii, 1897, p. 312.

† Though it is often difficult in practice to separate the normal quartz-mica-diorite from the granodiorite, it would seem suitable to restrict granodiorite to the following limits:

SiO_2	59–69	per cent.
Al_2O_3	14–17	"
Fe_2O_3	$1\frac{1}{2}$–$2\frac{1}{4}$	"
FeO	$1\frac{1}{2}$–$4\frac{1}{2}$	"
CaO	3–$6\frac{1}{2}$	"
MgO	1–$2\frac{1}{2}$	"
K_2O	1–$3\frac{3}{4}$	"
Na_2O	$2\frac{1}{2}$–$4\frac{1}{2}$	"

diorite and, more rarely, toward granite, may be found, but they are local and do not cover large areas, while the normal granodiorite is the prevailing rock of the Sierras. Comparing the type here described with the granodiorites of the many smaller areas enclosed in the slates on the western flank of the range, it can be stated that the latter as a rule approach more closely to the quartz-diorites, the percentage of lime being higher and the percentage of potash more often smaller than equal to that of soda. A few of these smaller granitic areas could, in fact, almost as well be indicated as quartz-mica-diorites. In the general habit, however, in the percentage of quartz, hornblende, and biotite, and in the constant presence of titanite, they are entirely similar to the granodiorites of the High Sierra. Microcline, not common in the granodiorites of the foothill region, occurs abundantly in those of the High Sierra.

A. Table of Complete Analyses.

	Granodiorite.					
	I.	II.	III.	IV.	V.	VI.
SiO_2	65·54	66·65	63·85	67·45	66·40	59·48
TiO_2	·39	·38	·58	·58	----	·93
Al_2O_3	16·52	16·15	15·84	15·51	17·13	17·25
Fe_2O_3	1·40	1·52	1·91	1·76	----	2·15
FeO	2·49	2·36	2·75	2·21	3·77	4·06
MnO	·06	·10	·07	----	----	·11
CaO	4·88	4·53	4·76	3·60	4·05	6·50
SrO	----	tr.	tr.	----	----	tr.
BaO	----	·07	·06	----	----	·09
MgO	2·52	1·74	2·07	1·10	·97	2·67
K_2O	1·95	2 65	3·08	3·66	2·08	2·27
Na_2O	4·09	3·40	3·29	3·47	4·49	3.53
Li_2O	----	tr.	tr.	----	----	tr.
H_2O below 100°C.	----	·18	·28	·14	----	·09
H_2O above 100°C.	·59	·72	1·65	·63	1·03	·71
P_2O_5	·18	·10	·13	·12	----	·33
	100·73	100·55	100·32	100·23	100·22	100·17

I. Lincoln, Placer Co., Sacramento Folio, W. F. Hillebrand analyst.
II. Nevada City, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
III. Grass Valley, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
IV. 103 Pyr. Pk., Silver Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
V. El Capitan, Yosemite, Cl. King.
VI. 398 Placer Co., Donner Pass, Truckee Folio, W. F. Hillebrand analyst.

The following of the rocks in table B belong to smaller areas enclosed in metamorphic rocks: IV, V, VII, VIII, IX, X. The following numbers represent the great areas in the higher part of the Sierra Nevada: I, II, III, VI, XI, XII, XIII, XIV, XV, XVI, XVII.

B. TABLE OF PARTIAL ANALYSES OF GRANODIORITES.

	I	II	III	IV	V	VI	VII	VIII	IX
SiO_2	59·48	63·54	62 17	----	----	----	----	65·54	63·85
CaO	6·50	6·11	5·80	5·64	5·64	5·41	5·37	4·88	4·76
K_2O	2·27	1 91	2·23	1·18	1·18	1·82	1·60	1·95	3·08
Na_2O	3·51	2 97	2·86	3·74	3·74	3 15	3·81	4·09	3·29

	X	XI	XII	XIII	XIV	XV	XVI	XVII
SiO_2	66·65	65·88	67·14	66·40	68·13	67·45	68·32	69·85
CaO	4 53	4·11	4·07	4·05	3·51	3 60	3·21	3·08
K_2O	2·65	2·88	2·70	2·08	3 58	3·66	3·37	2·28
Na_2O	3 40	2 41	3 09	4·49	3·13	3 47	2·51	4 13

LOCALITIES OF SPECIMENS IN TABLE B.

I. 398 Placer Co. Donner Pass, Truckee Folio. Geo. Steiger analyst.
II. 225 Nevada Co., 2 miles S. of Faucherie Lake, Colfax Folio, Geo. Steiger analyst.
III. 221 Nevada Co., 1 mile S. W. of Faucherie Lake, Colfax Folio, Geo. Steiger analyst.
IV. 338 El Dorado Co, 1¼ mi. S. of Fairplay, Placerville Folio, W. H. Melville analyst.
V. 293 Placer Co., Penryn, Sacramento Folio, W. H. Melville analyst.
VI. 305 El Dorado Co. Point between Soldier Creek and South Fork of American River, Placerville Folio, W. H. Melville analyst.
VII. 104 El Dorado Co White Rock Cr., Placerville, Placerville Folio, W. H. Melville analyst.
VIII. Lincoln, Placer Co., Sacramento Folio, W. F. Hillebrand analyst.
IX. Nevada City. Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
X. Grass Valley, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
XI. 177 Pyramid Pk., Meeks Creek, Lake Tahoe, Truckee Folio, Geo. Steiger analyst.
XII. 86 Pyramid Pk., Rockbound Lake, Truckee Folio, Geo. Steiger analyst.
XIII. El Capitan, Yosemite, Cl. King.
XIV. 69 Pyramid Pk., 1½ mi. S. of Rubicon Point, Truckee Folio, Geo. Steiger analyst.
XV. 103 Pyramid Pk., Silver Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
XVI. 120 Pyramid Pk., Big Mud Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
XVII. 231 Nevada Co., Rattlesnake Cr., 2 m. N. E. of Cisco, Truckee Folio, Geo. Steiger analyst.

Characteristic features and limits of granodiorite.—Under the term granodiorite are included light-colored granular rocks, composed of quartz, oligoclase or andesine, orthoclase, biotite or hornblende or both, titanite, magnetite, apatite and zircon. The average grain ranges from 1 to 4^{mm}, but certain of the minerals sometimes considerably exceed this. Thus the hornblende prisms are often 10^{mm} long and those of orthoclase may be still larger. The fresh outcrops are brilliantly grayish white, and even when decomposed the amount of ferric oxide set free is rarely sufficient to impart a red color to the rock.

In thin section the structure is typically hypidiomorphic. The biotite and hornblende are sometimes, the soda-lime felds-

spars nearly always partly idiomorphic; these minerals are usually cemented by a later consolidated mass of orthoclase and quartz. The orthoclase may, in types relatively rich in K_2O, assume the form of microcline; albite and perthitic growths are ordinarily absent, but the latter have been noted in small amounts. The soda-lime feldspar generally ranges from Ab_7An_3 to Ab_2An_1; and is always either a basic oligoclase or an andesine; acid oligoclase or varieties containing more lime than andesine are absent. The biotite is a dark brown normal variety with small but distinct angle between the optic axes. The hornblende is green or brownish-green with a maximum extinction of 18°–20°. Pyroxene (augite) is known as kernels in hornblende, though the latter is certainly not of secondary origin. It is by no means impossible that granodiorites with a notable amount of pyroxene may be found, but they certainly are not very common and represent no widely spread type. In the normal types both biotite and hornblende are usually present. But either one may occasionally be sparingly represented or even absent. Titanite is an always present constituent of the rock. Magnetite is only present in small quantities.

C. TABLE OF MINERALOGICAL COMPOSITION OF GRANODIORITE.

Numbers correspond to Table A.

	II	III	IV
Potassium feldspar	15·	18·	17·75
Sodium feldspar	29·^{a}	28·$^{a'}$	29·41$^{a''}$
Calcium feldspar	15·^{b}	12·10$^{b'}$	11·91$^{b''}$
Biotite / Hornblende	16·		12·79
Hornblende		16·60	
Quartz	22·	20·80	25·71
Apatite	·24	·30	·30
Magnetite	1·50	1·50	·84
Titanite	1·	1·40	1·40
Total	99 74	98·70	100·11

$a + b = 44· = Ab_2An_1$, with 34 per cent An.
$a_{\prime} + b_{\prime} = 40·1 = Ab_7An_3$, with 30 per cent An.
$a_{\prime\prime} + b_{\prime\prime} = 41·32 = Ab_7An_3$, with 29 per cent An.

The chemical composition of the granodiorites in the Sierra Nevada is characterized by a percentage of silica neither very high nor very low, ranging from 59 to 69 per cent. The iron and magnesia are relatively low, the lime on the contrary ranging between 3 per cent and 6·50 per cent, though the latter limit is rarely reached. The sum of the alkalies ranges from 4·92 to 7·13 and thus may notably exceed the lime, but never fall short of it more than one per cent. As to the relation between K_2O and Na_2O the latter is apt to predominate, rang-

ing from 2·50 per cent to $4\frac{1}{2}$ per cent. K_2O varies in the analyses from 1·18 per cent to 3·66 per cent and may equal or even slightly exceed Na_2O, especially in the more acidic types from the High Sierra. Where the percentage goes below 1· the rocks should certainly be classed as quartz diorites.

The above tables give complete analyses of six granodiorites, partial analyses of seventeen rocks, and the calculated mineralogical composition of three rocks.

Regarding VI in Table A and I in Table B of incomplete analyses, it should be stated that, owing to the low percentage of silica and large amount of iron and magnesium, it stands close to the limit and may be considered as a quartz-diorite or a granodiorite. That it has been included in this table is due to the fact that these changes from the composition of a normal granodiorite have only been effected by the addition of hornblende without much altering the proportion and composition of the feldspars.

Another somewhat doubtful rock is XVI in the second table, which has a high percentage of K_2O coupled with an unusually small amount of Na_2O, and it is probable that it represents a local facies of the prevailing rock. Its composition would probably place the rock close to the quartz-monzonites.

The last tables give the calculated mineralogical composition of three representative rocks. For the determination of the potash feldspar all of the K_2O except the quantity needed for biotite has been used. Similarly all of the Na_2O, deducting a small amount for the hornblende, has been calculated as albite. All of the albite has been added to the anorthite as soda-lime feldspar. The potash-feldspar undoubtedly contains some soda but that it is only a small amount, is shown by the fact that microperthite, albite and anorthoclase are not generally present and, furthermore, because the calculated soda-lime feldspar closely agrees in composition with that inferred from optical measurements.

Regarding the "average composition" quoted above from my report on Nevada City and Grass Valley, it should be borne in mind that most of the analyses available in 1896 were made of the more basic type of granodiorite, so that the lime is a little higher and potash lower than would be the case if the large areas of the somewhat more acidic type of the High Sierra were considered. It is clear besides that it will be very difficult to obtain such an average, for not only the analyses but the weight in proportion to the rock masses should be considered.

I have no radical change to propose in the chemical limits of the rock given in the paper on the Pyramid Peak region, referred to on page 272. Only, as to the percentage of silica it

should be stated that the granodiorites *of the Sierra Nevada* vary between 59 and 69 per cent; but just as granites and quartz-diorites include rocks with up to 74 per cent or even more of silica, so should the family of the granodiorites include similar acidic types, though they do not appear to be of very common occurrence.

In regard to the lime it may be said that the upper limit (6·50 per cent) is rarely reached and when at the same time the potash approaches 1 per cent the rock should rather be classed as a quartz-diorite. When the percentage of silica falls below 59 the percentage of orthoclase is usually also lowered to such a degree that the rocks become diorites.

With high silica in rocks which otherwise correspond exactly to the composition of a granodiorite the lime is apt to fall low and may in rocks closely related to monzonites even descend to 2·80 per cent.

The truly characteristic features of the granodiorites is that the soda-lime feldspar, which always is a calcareous oligoclase or an andesine, is *at least* equal to double the amount of the alkali feldspar. The latter may be taken to vary from 8 per cent to 20 per cent. Below the lower limit the rock becomes a quartz-diorite: above the upper a quartz-monzonite.

Distribution of types.—As with all other classes of rocks, granodiorite presents somewhat varying types in different localities. Many of the intrusive areas in the foothill region and on the middle slopes of the Sierra Nevada are associated with normal diorites, quartz-diorites and gabbros. As a consequence of the generally more basic character of the magma, the granodiorite of the foothills shows a basic type with relatively higher percentage of lime and lower of potash (see IV, V, VI, VII). In the great granitic areas of the Sierra the general type of the magma is more acidic, hence the granodiorite tends more towards an acidic type without exceeding the limits of the family. However, extensive masses of granodiorites of the more basic type (as well as diorites) exist on the quadrangles of Truckee and Colfax, in the High Sierra. These two types resemble each other so much that their separation in the field appears entirely impracticable. From a cursory examination it appears probable that much of the granitic masses of Southern California belong to the granodiorites. A large part of those of the peninsular range of Lower California are certainly granodiorites, as I have shown by microscopical examination and separation by Thoulet Solution.*

Relation to allied rocks.—In 1895 Prof. W. C. Brögger established the new family of the monzonites,† rocks intermediate in composition between granite and diorite.

* Proc. Cal. Acad. Sci., 2nd Ser., vol. i, part 2, p. 6, 1888.

† Die Eruptionsfolge der triadischen Eruptivgesteinen bei Predazzo in Südtyrol. Kristiania, 1895, p. 19.

In view of this it may be profitable to inquire into the limits assigned to this rock and to its relation to granodiorite.

In order to make accurate comparisons it is necessary to have accurately defined standards; the lack of these is very much felt in attempts at rock classification. "Granite" is a term concerning the petrographic meaning of which there can be little doubt. True, certain geologists have fallen into the habit of using this name as a synonym for "granular rocks," but this is a practice which should not be encouraged.*

A granite means petrographically a granular rock composed of quartz and alkali feldspar with a micaceous mineral or hornblende. There are, however, but few rocks which exactly correspond to this type, more or less soda-lime feldspar being ordinarily present; it may be referred to as an *extreme* type from which the rock can vary only one way, and the majority of our granites are therefore more or less pronouncedly intermediate between granite and diorite.

Diorite is ordinarily defined (Rosenbusch) as a granular rock composed of soda-lime feldspar, and biotite, pyroxene, or amphibole singly or severally; with added quartz the family of the quartz-diorites is formed. While this is the most generally accepted definition, some petrographers deny admission into this family to the varieties carrying pyroxene. It will be apparent at a glance that unless the very wide term soda-lime feldspar is qualified, this family would include diabases and gabbros as well, and to make separate families of the latter is to sacrifice logical classification. What is really done for practical purposes is expressed by Brögger as follows:† "Die einzige moegliche Trennung wird hier nach meiner ansicht diejenige sein, den Begriff Diorit für mittelsaure Tiefengesteine, den Begriff Gabbro für basische Tiefengesteine der Plagioklasreihe, den Namen Diabas für entsprechende hypabyssische Gesteine und für palaiotype‡ Ergussteine zu reserviren." Assenting to this limitation, it is still true that diorite and quartz-diorite, owing to the variation of soda-lime feldspars, is a less precise term than granite.

It became apparent to Prof. Brögger, as it did to the Californian geologists, that the terms granite, diorite and quartz-diorite were no longer sufficient for present purposes, and this necessity of special names for transition types or intermediate rocks is often expressed in his writings. The result was the

* "Granolites" has been proposed as a convenient word, embracing all rocks of granular structure, and though open to criticism in some respects certainly offers some advantages. See H. W. Turner, Journal of Geology, 1899, p. 141.

† l. c. p. 17.

‡ American petrographers will probably object to this limiting of diabase; the Columbia (Miocene) lava formation, for example, contains abundant instances of diabase flows.

proposal to establish the new family of the monzonites intermediate between the syenites and the diorites, and that of the quartz-monzonites intermediate between the granites and the quartz-diorites. The kernel of the definition of these rocks is contained in the following words :* "Das wirklich characterische bei diesen Gesteinen, ist dass sie in der Regel Orthoklas und Plagioklas ungefähr gleich reichlich oder jedenfalls beide reichlich führen." On the same page we read "Die Monzonite characterisiren sich dadurch dass sie weder zu den Orthoklas-Gesteinen noch zu den Plagioklas-Gesteinen, sondern zu einer Uebergangsgruppe zwischen beiden gehören, sie sind eben: Orthoklas-Plagioklas-Gesteine." In the same place Prof. Brögger states that in his opinion, in order to apply the name diorite, the soda-lime feldspars must strongly predominate; in granite, on the other hand, the alkali feldspars must strongly predominate or (see footnote) the plagioclase must be so acid that the rock is very poor in lime.

In the above definition there is no special limit assigned to the soda-lime feldspars, so that the permissible variation becomes rather large. It must be apparent, however, that the author intended the rock in its most typical development to be placed exactly half way between the granites and the quartz-diorites so far as the feldspars were concerned. This view is corroborated by the fact that of the two calculated analyses given, the first —a monzonite—has 30 per cent orthoclase and 32 per cent soda-lime feldspar (Ab_3An_2) and the second—a quartz-monzonite—(p. 62, l. c.), 35·5 per cent orthoclase and 31·5 per cent Ab_2An_3.

Thus the term quartz-monzonite becomes a *central* type embracing a series of rocks on each side of the definition. Just how far Brögger intended to extend these limits is not clearly stated.

There is undoubtedly ample justification for the introduction of the term quartz-monzonite as defined by Brögger, but reasonable limits should be assigned to it. It would manifestly be incorrect to define a family as having approximately equal amounts of orthoclase and soda-lime feldspars and then include in it rocks having three or four times as much of one as of the other. The definition of granodiorite would give it, say from 8 per cent to 20 per cent orthoclase. In the quartz-monzonites I would give this mineral a range from 20 per cent to 40 per cent, all in an assumed total of 60 per cent feldspars. The rocks containing more than 40 per cent orthoclase would then be classed as granites, there being scarcely room for another family between the quartz-monzonites and the granites.

*l. c. p. 21.

In this manner the former family becomes quite extensive and certainly includes wider limits than does granodiorite. In a postscript to his discussion of the rocks from Monzoni (p. 182) Prof. Brögger devotes a few paragraphs to granodiorites, stating that according to the analysis (No. I in Table A) the rock clearly belongs to the quartz-diorites or rather to the small group between the diorites and the quartz-diorites. He finally concludes that granodiorite is not used in the same sense as quartz-monzonite but rather as a synonym for tonalite. This view is clearly due to the fact that Brögger only recognizes one intermediate group, placing it exactly in the middle between the granites and the quartz-diorites. The above discussion has sufficiently set forth that granodiorite is not a synonym for quartz-mica-diorite or tonalite, which is a typical rock of that kind, except in this sense that many petrographers have formerly used the term quartz-mica-diorite, in absence of others, for rocks comparatively rich in orthoclase.

It has been proposed* by Mr. Turner to class rocks of the composition of IV (and consequently also rocks like III) in Table A as quartz-monzonites. This can only be done by disregarding the definition given by Prof. Brögger of this latter rock. No. IV contains 17·75 per cent orthoclase and 41·40 per cent soda-lime feldspars; this is clearly a rock in which the latter feldspars *greatly predominate* and not a rock with approximately equal quantities of the two feldspars.

Taking an example to the point, there are in Idaho large areas of a granular rock having the following composition :

SiO_2	68·48
Al_2O_3	15·01
FeO	2·90
CaO	2·60
MgO	1·21
K_2O	4·25
Na_2O	3·22
Rest.	2·33
	100·00

From the data obtained by microscopic examination, this rock may be calculated as follows :

Alkali feldspar	21·
Oligoclase	34·
Biotite	13·
Quartz	29·
Accessories	3.
	100·

* H. W. Turner, The Granitic Rocks of the Sierra Nevada. Journal of Geology, 1899, p. 141.

Owing to the low percentage of CaO and large amount of K_2O this rock would fall outside of the limits of granodiorite and may approximately be referred to as a quartz-monzonite. This rock has all the appearance of a granite, and from field examination was supposed to belong to that family.

In the critical examination of proposed rock types the definition is clearly first to be considered, secondarily the analyses. Turning now to the analyses of quartz-monzonites given by Brögger, a perusal will convince that representatives of his definition are few in number. The group with less silica or the banatites is represented by five analyses, four of which easily fall within the limits of the granodiorites. The mean of the analyses is as follows:

	Adamellite.	Banatite.
SiO_2	69·27	64·39
Al_2O_3	13·47	15·90
Fe_2O_3	4·82	4·69
CaO	3·25	4·15
MgO	1·02	1·93
K_2O	3·85	3·52
Na_2O	3·29	3·58

By reason of the high potash the adamellite of this average falls outside of the granodiorites though it hardly corresponds to Brögger's definition. The banatite, on the other hand, would be identical with some types of granodiorite if the analyses were actually representative. Brögger's average of banatite is thus not only on one side of his definition but very much so, inasmuch as the soda-lime feldspar will be equal to about three times the quantity of orthoclase, provided that the mineral composition of the rocks is similar to that of a granodiorite.

I think in fact that it will be difficult to obtain any considerable number of analyses of granular rocks, having the average silica content of 65 per cent and about equal quantities of alkali and soda-lime feldspars. In other words, it does not appear probable that the banatite, which corresponds to Brögger's definition, is a very common and widespread family of rocks.

Granodiorite porphyry.—Minor intrusive masses and dikes, having the composition of granodiorite combined with a porphyritic holocrystalline groundmass, are not uncommon. For these I propose the name granodiorite porphyry, in analogy with granite porphyry and diorite porphyry.

Conclusions.—Granodiorite, a member of the great family of rocks with predominating soda-lime feldspars, is distinguished by a granular texture, grayish color and a mineral

composition of quartz, oligoclase or andesine, orthoclase or microcline, hornblende or biotite (usually both); the accessories being titanite, apatite, magnetite and zircon. The quartz may average 23 per cent, the soda-lime feldspars 44 per cent, the orthoclase (with microcline and albite) 14 per cent, varying from 8 per cent to 20 per cent, the ferro-magnesian silicates 14 per cent. These figures are not claimed to be an exact average, which in the nature of the case is difficult to obtain, but they correspond to a fairly typical rock. The family is proposed to represent a very important and very widespread type of rocks, especially common along the Pacific slopes of the Cordilleran Ranges. This family has been clearly defined; the name has for many years been in use in the folios of the U. S. Geological Survey. It has found rapid and general acceptance by reason of its simple construction and its implied definition. But chiefly and above all it deserves to stand because representing a natural group of rocks.

Washington, D. C., December, 1899.

Art. XXVIII.—*Two new American Meteorites;* by H. L. Preston.

Luis Lopez, New Mexico.

The Luis Lopez siderite is somewhat rectangular in shape and measures 80 × 130 × 195^{mm} in its greatest diameters; it is the property of Prof. Henry A. Ward of Chicago.

When received by Prof. Ward, it was entire, lacking possibly 40 or 50 grams that had been sawn off one of the prominent protuberances. The actual weight when received was 6,903 grams. The general shape of the mass was quite symmetrical and covered on all sides with large and prominent pittings.

The outer surface was entirely covered, save the small cutting, with a rather lustrous reddish-brown crust. On cutting the mass, numerous troilite nodules ranging in size from 8 to 28^{mm} in diameter were found, some sections containing as many as four nodules of large size. There were numerous straight fissures one millimeter or less in thickness, and from 40 to 70^{mm} in length, which are filled with troilite.

On etching the surface of these sections, the Widmanstätten figures are brought out, sharp and distinct; they are typically octahedral, and composed of broad laminæ, the kamacite bands being from 1 to 3^{mm} in diameter, and up to 41^{mm} in length, in some cases without a break.

There are also numerous small streaks or seams of schreibersite, the longest as far as observed being 8^{mm} and a trifle less than 1^{mm} in width.

The troilite nodules are likewise surrounded by a very narrow band of schreibersite, which presents a strong contrast between the silvery white kamacite bands and the bronze-colored troilite nodules. In some few instances, a black graphitic substance, from 1 to 3^{mm} in width, is seen surrounding the troilite nodules, between the narrow band of schreibersite and the kamacite. The minute hair-like lines commonly called laphamite markings are abundant in the rhomboidal patches known as plessite. These lines are caused by minute alternating layers of kamacite and tænite, plessite, as proved by J. M. Davison, being formed in this way, and not a different nickel-iron alloy as formerly supposed.

This meteorite was found in the early part of 1896 by a Mexican named Gonzales, who was very reticent for a long time about giving its exact locality, supposing he had found indications of a valuable mine. But later Mr. C. T. Brown of Socorro, New Mexico, succeeded in obtaining the mass, and

was informed by the Mexican that he had made further search for more pieces but found none. He had picked this piece up about five miles southwest of Socorro, near the hamlet of Luis Lopez.

In the autumn of 1896, the mass as found passed into the possession of Mr. A. B. Fitch of Magdalena, N. M., who retained it in his possession until June, 1899, when it was purchased by Prof. Ward.

From its near proximity to the above hamlet, we will designate this siderite as the *Luis Lopez meteorite*, Socorro County, New Mexico.

An analysis by Mariner and Hoskins of Chicago gave

Fe	91·312
Ni	8·170
Co	·160
Si	trace
P	·333
S	·013
C	·012
	100·

Specific gravity .... 7·7.

As this portion of New Mexico has been somewhat prolific in new meteorites within the past few years, it is perhaps advisable to note the relation of this find to five others, making a total of six siderites found in a parallelogram of about three hundred miles by ninety.

1st. We have the *Costilla Peak* of about 35 kilograms, found in August, 1881, on the north slope of Costillo Peak about 210 miles N.N.E. of Socorro, described by R. C. Hills.

2d. *Glorieta Mountain.* Three masses of 24·26, 53·38 and 67·12 kilograms, that were apparently portions of the same mass originally, and several smaller pieces found in May, 1884, on Glorieta Mountain, 120 miles N.N.E. of Socorro, described by Geo. F. Kunz.

3d. *El Capitan*, of about 28 kilograms, found in 1893 on the north slope of El Capitan Mountain, 90 miles S.E. of Socorro, described by E. E. Howell.

4th. *Sacramento Mountain.* 237 kilograms, surmised to have fallen in 1876 and found on the eastern slope of the Sacramento Mountains 120 miles S.E. of Socorro, described by Warren M. Foote.

5th. The *Oscuro Mountain*, of about 6 kilograms, found in three pieces Dec. 10th, 1892, in the eastern foot hills of the Oscuro Mountains, about 35 miles S.E. of Socorro, described by R. C. Hills.

6th. The present siderite, *Luis Lopez*, 6·9 kilograms, found in 1896, five miles S.W. of Socorro.

It is absolutely certain that these six finds represent six distinct falls of meteorites, as proved first by the analyses:

	Fe	Ni
Costilla	91·65	7·71
Glorieta	87·93	11·15
El Capitan	90·51	8·40
Sacramento Mts.	91·39	7·86
Oscuro	90·79	7·66
Luis Lopez	91·31	8·17

Secondly, the crystalline structure, as shown by the Widmanstätten figures, is so entirely different that it would be impossible to confound either one with any other of these finds.

Central Missouri.

The history of this most interesting siderite as to the exact date when found, and the precise locality where found, has been entirely lost.

The weight of the whole was probably about 25 kilograms. An end piece apparently about half the entire mass, weighing 12,360 grams, has been deposited for many years in the Western Reserve Historical Society of Cleveland, Ohio, while the other half was in the collection of the late Prof. Wm. Denton of Wellesley, Mass. Through the Librarian of the Western Reserve Historical Society, Prof. J. P. MacLean, Prof. Ward has obtained a large portion of this piece.

The outer surface of the mass is most beautifully and typically pitted, and of a dark reddish-brown color, with the exception of the prominent ridges, which are of a lustrous dark steel-gray color, resembling graphite, although it does not soil paper when rubbed over it.

On cutting the mass, we found numerous fissures meandering in various directions over the entire surface. A few of the largest are one millimeter in diameter, and are filled in part by a black graphite-like substance, and in part by schreibersite. There are also patches of schreibersite, resembling hieroglyphics, some of them 5 by 25^{mm} in diameter, scattered here and there over the surface. A few prominent troilite nodules are visible on the sections, the largest being 9×15^{mm} in diameter. On etching the iron no figures whatever are brought out, leaving only a minutely pitted light gray surface, which is more or less clouded.

The only history of the finding of this siderite as furnished by Prof. J. P. MacLean from the records of the Western Reserve Historical Society, is as follows:

"This meteorite was found in the fifties in Central Missouri, and after being cut in halves, one-half went to the late Prof. Wm. Denton and the other half was purchased of Mrs. Newcomer (of Cleveland) by the late Judge C. C. Baldwin, and by him presented to the Society."

An analysis of this siderite by Mariner and Hoskins of Chicago gave

Fe	94·734
Ni	4·620
Co	·180
P	·442
S	·015
C	·009
	100·

Specific gravity, 7·5.

The small amount of carbon is probably due to the fact that the portion of the mass used for analysis was free from the black graphite-like veins.

As no more definite locality can be traced as the location in which this iron was found, we will designate for this iron the name, Central Missouri.

ART. XXIX.—*On the Best Form for the Double Achromatic Objectives of Telescopes ;** by WM. HARKNESS.

WHEN the thicknesses and distances apart of the two component lenses are so small that they can be neglected, the curvatures of the surfaces of these lenses are the only disposable constants for satisfying the equations which determine the properties of a double achromatic objective. As there are four of these surfaces, four conditions can be satisfied. Three of them are always employed in determining the focal length of the objective, its color correction, and the correction for spherical aberration of rays proceeding from an infinitely distant point lying in the optical axis of the telescope. For the disposition of the remaining constant various conditions have been proposed, among which the following may be mentioned because they have secured a prominent place in optical practice:

In 1756 Clairaut† suggested that the interior surfaces of the crown and flint lenses should have the same curvature, in order that they might be cemented together, and that plan has since been almost universally adopted in all spy and binocular glasses. In 1778 Klügel proposed that the crown lens should be made equi-convex, in order to secure with a given thickness of glass the shortest possible focal distance, or, in other words, the greatest possible angular aperture; and in 1810‡ he proposed that the radii of the outer and inner surfaces of the crown lens should be to each other as 1:3, or more exactly as $(2-n):n$, where n is the refractive index of the glass. The method of determining the curves of the objective when the crown is equi-convex was greatly improved by Littrow in 1827§ and since then that construction has been much employed under the name of Littrow's objective. In 1816 Bohnenberger wrote a paper to show that the spherical and achromatic aberrations were best corrected by making the radii of the outer and inner surfaces of the crown lens in the ratio of 2:3, and that construction has also found much favor. Finally, about 1824 or 1825 Fraunhofer introduced a form of objective which is certainly superior to any previously known, but he never gave its theory, and because it is rather more difficult to make and adjust than the forms advocated by Clairaut, Klügel, Littrow and Bohnenberger, it has never been popular with practical opticians.

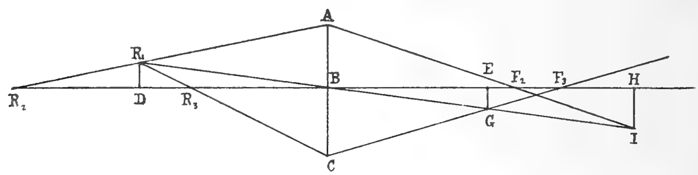
* This paper, in a slightly different form, was read before the Philosophical Society of Washington on October 28, 1893.

† Mem. Paris Acad., 1756, p. 431.

‡ Gilbert's Annalen, 1810, xxxiv, 280.

§ Mem. Roy. Ast. Soc., 1827, vol. iii, pp. 235–255.

The conditions which should be satisfied by a perfect objective are, first, that it shall have a specified focal length; second, that its achromatic aberration shall be corrected, which, strictly speaking, would include the destruction of the secondary spectrum, but that point will not be considered in the present paper; and third, that its spherical aberration shall be corrected, not only for distant objects lying in its optical axis, but for all objects, whether near or remote, situated anywhere within its field of view. It has been surmised that the latter condition was what Fraunhofer aimed at in the object-glasses which he constructed, but I am not aware that the mathematical theory involved in the said condition has ever been formulated, and, therefore, it seems worth while to examine it here.



Referring to the figure, let AC be a thin lens whose optical axis is R_2H, and let F_2 and F_3 be, respectively, the focal points for axial rays proceeding from the radiants R_2 and R_3. Furthermore, let R_1 be an oblique radiant situated on the straight line joining R_2 with A, and let the rays R_1AI and R_1CG proceed from it. The straight line R_1BGI, passing through the optical center of the lens, will be intersected by them at G and I, and consequently images of R_1 will be formed throughout the entire interval between these points. Finally, draw the lines R_1D, EG and HI perpendicular to the optical axis R_2H.

For brevity let

F = Principal focal distance of the lens AC.
y = $AB = AC$ = semi-diameter of the lens AC.
R_1 = Distance DB. F_2 = Distance F_2B.
R_2 = Distance R_2B. F_3 = Distance F_3B.
R_3 = Distance R_3B. ω = The angle $R_1BD = IBH$.

An examination of the figure shows that the oblique spherical aberration arising from the eccentric position of the radiant R_1 is represented by the interval EH between the images at G and I, and in order to destroy it, the point G must be made to coincide with the point I. That will be the case when $BE = BH$, and we have now to inquire what conditions must subsist in order to bring about this equality.

From the figure we have

$$y : F_3 :: BE \tan \omega : F_3 - BE$$

whence,

$$BE = \frac{yF_3}{y + F_3 \tan \omega} \tag{1}$$

and again from the figure

$$y : F_2 :: BH \tan \omega : BH - F_2$$

whence,

$$BH = \frac{yF_2}{y - F_2 \tan \omega} \tag{2}$$

Then, to make $BE = BH$, we equate the right hand members of (1) and (2) and obtain

$$\frac{F_2}{y - F_2 \tan \omega} = \frac{F_3}{y + F_3 \tan \omega} \tag{3}$$

which is the condition for the destruction of the oblique aberration.

If now we suppose the spherical aberration of the lens AC to be perfectly corrected for all objects situated in its axis, whether near or far, and if F_2 and F_3 are the focal points for rays diverging respectively from the radiants R_2 and R_3 then we shall have rigorously, for all points of the lens

$$\begin{aligned} 1/F &= 1/F_2 + 1/R_2 \\ 1/F &= 1/F_3 + 1/R_3 \end{aligned} \tag{4}$$

From the figure

$$R_2 - R_1 : R_2 :: R_1 \tan \omega : y$$

whence,

$$\frac{1}{R_2} = \frac{1}{R_1} - \frac{\tan \omega}{y} \tag{5}$$

and again from the figure

$$R_1 - R_3 : R_3 :: R_1 \tan \omega : y$$

whence,

$$\frac{1}{R_3} = \frac{1}{R_1} + \frac{\tan \omega}{y} \tag{6}$$

By substituting the right hand members of (5) and (6) in (4), we obtain,

$$\frac{1}{F} - \frac{1}{R_1} = \frac{1}{F_2} - \frac{\tan \omega}{y} = \frac{1}{F_3} + \frac{\tan \omega}{y}$$

whence,

$$\frac{F_2}{y - F_2 \tan \omega} = \frac{F_3}{y + F_3 \tan \omega} \tag{7}$$

which is identical with (3); and as the validity of (7) depends only upon the exact fulfillment of the condition expressed by the equations (4), while (3) implies the destruction of the oblique aberration, we conclude that

If in any thin lens the spherical aberration is completely corrected for all objects situated in the axis of the lens, then the oblique aberration will also be completely corrected.

Thus the problem of obtaining equally distinct images in all parts of the field of view is reduced to the problem of making the destruction of the spherical aberration for axial rays independent of the distance of the radiant from the telescope, and we have now to inquire how far that can be done in the case of double achromatic objectives. Fortunately the latter problem is not new, having presented itself to Sir J. F. W. Herschel so long ago as 1821, when he showed that the spherical aberration of an achromatic objective consisting of any number of thin lenses in contact can be expressed in the form

$$\Delta f = \tfrac{1}{2} y^2 \left(X + YD + ZD^2 \right) \tag{8}$$

where y is the semi-aperture of the objective, X, Y and Z are functions of the refractive indexes and focal distances of the several lenses, and of the radii of curvature of their first surfaces, and D is the reciprocal of the distance of the object viewed. Of course the refractive indexes are known, and the focal length of the objective together with the achromatic equation determine the focal distances of the several lenses. Consequently equation (8) contains as indeterminates only the radii of curvature of one surface of each lens; and in the case of a double objective, two independent conditions suffice to determine them. Herschel concluded that these conditions should be

$$X = 0 \qquad Y = 0 \tag{9}$$

because the term depending on D is thus destroyed for all distances of the radiant, and although the term in D^2 still remains, it is usually small enough to be neglected whenever D does not exceed 0·01 of the length of the telescope. He summed up the situation by saying,*

"If these equations be combined, we shall obtain the dimensions of an object-glass free from aberration, both for celestial and terrestrial objects, provided we restrict our views to objects situated in the prolongation of the axis of the telescope."

That proviso is shown by the present paper to be a mistake, but from Herschel's point of view it seemed necessary, because his equations contained no explicit provision for the destruction of the lateral aberration.

* Phil. Trans., 1821, p. 260.

The equations (9) are of the second degree, and consequently give two sets of radii. Herschel preferred that set which gave the flattest curves to the lenses, and it is to be remarked that the resulting objectives resemble those constructed by Fraunhofer so closely as to be practically undistinguishable from them.

In double achromatic objectives of Herschel's form the four disposable constants are employed as follows:

1. To determine the focal length of the objective.

2. To correct the chromatic aberration for rays of some definite wave length.

3. To correct the spherical aberration of central rays proceeding from infinitely distant objects.

4. To correct the spherical aberration of central rays, so far as the first power of the distance is concerned, for all objects, no matter what their distance from the telescope.

From what precedes it is evident that the last condition carries with it the destruction of the lateral spherical aberration up to the locus where the term in D^2 becomes sensible, and as that term is practically indestructible, we conclude that objectives of the Herschel form excel all others consisting of two lenses in contact in being aplanatic throughout the largest possible field of view, and for objects over the greatest possible range of distance. In meridian circles, transit instruments, zenith telescopes, photographic telescopes, and all other instruments where good definition is required over an extensive field, this is of the utmost importance, but for equatorial telescopes it is of less consequence, because their more restricted fields scarcely permit the lateral aberration to become sensible.

Washington, D. C., Feb. 6, 1900.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Passage of Argon through thin Films of India-rubber;* by Lord Rayleigh.—Soon after the discovery of argon it was thought desirable to compare the percolation of the gas through india-rubber with that of nitrogen, and Sir W. Roberts-Austen kindly gave me some advice upon the subject. The proposal was simply to allow atmospheric air to percolate through the rubber film into a vacuum, after the manner of Graham, and then to determine the proportion of argon. It will be remembered that Graham found that the percentage of *oxygen* was raised in this manner from the 21 of the atmosphere to about 40. At the time the experiment fell through, but during the last year I have carried it out with the assistance of Mr. Gordon.

The rubber balloon was first charged with dry boxwood sawdust. This rather troublesome operation was facilitated by so mounting the balloon that with the aid of an air-pump the external pressure could be reduced. When sufficiently distended the balloon was connected with a large Toepler pump, into the vacuous head of which the diffused gases could collect. At intervals they were drawn off in the usual way.

The diffusion was not conducted under ideal conditions. In order to make the most of the time, the apparatus was left at work during the night, so that by the morning the internal pressure had risen to perhaps three inches of mercury. The proportion of oxygen in the gas collected was determined from time to time. It varied from 34 per cent when the vacuum was bad to about 39 per cent when the vacuum was good. On an average it was estimated that the proportion of oxygen would be about 37 per cent of the whole. The total quantity of diffused gas reckoned at atmospheric pressure was about 300^{cc} per twenty-four hours.

On removal from the pump the gas was introduced into an inverted flask standing over alkali, and with addition of oxygen as required was treated with the electrical discharge from a transformer in connection with the public supply of alternating current. In this way the nitrogen was gradually oxidized and absorbed. Towards the close of operations the gas was transferred to a smaller vessel, where it was further sparked until no further contraction occurred, and the lines of nitrogen had disappeared from the spectrum. The excess of oxygen was then removed by phosphorus.

It remains only to record the final figures. The residue, free of oxygen and nitrogen, from 3205^{cc} of diffused gas was 39^{cc}. The most instructive way of stating the result is perhaps to reckon the argon as a percentage, not of the whole, but of the nitrogen and argon only. Of the 3205^{cc} total, 2020^{cc} would be nitrogen

and argon, and of this the 39^{cc}·argon would be 1·93 per cent. Since, according to Kellas (Proc. Roy. Soc., vol. lix, p. 67, 1895), 100^{cc} of mixed atmospheric nitrogen and argon contains 1·19 per cent of argon, we see that in the diffused gas the proportion of argon is about half as great again as in the atmosphere. Argon then passes the india-rubber film more readily than nitrogen, but not in such a degree as to render the diffusion process a useful one for the concentration of argon from the atmosphere.—*Phil. Mag.*, Feb. 1900, p. 220.

2. *Influence of Water on the Combustion of Carbon Monoxide ;* by G. Martin. (Abstract.) Chemical News, vol. lxxxi, No. 2095. Jan. 19th, 1900.—The author believes that the action of water in facilitating the oxidation of CO cannot be expressed by one equation, but consists of several reactions—one predominating at one time, another at another time, according to the amount of H_2O and O_2 present. This accounts for the lengthening out of the explosion wave when the quantity of steam or O_2 present is diminished. As regards the mechanism of the process, the author believes that the H_2O molecule, by its "attractive power" (evidences of which he sees in the great dissociating power of water,) alters the motion of the atoms in neighboring molecules. This intramolecular alteration in strain, together with the presence of free O, determines the reaction—much in the same way that finely divided gold, etc., causes the decomposition of H_2O_2. This view explains the action of H_2O in dissociating NH_4Cl vapors,—the motion of the atoms within the NH_4Cl molecule being altered by the attractive power of H_2O, and thus it dissociates. The author considers the last case analogous to "supercooling" in liquids.

3. *The combination of sulphur dioxide with oxygen ;* by E. J. Russell and Norman Smith.—The authors have found that when a mixture of sulphur dioxide and oxygen acts on certain oxides, in addition to the absorption of the sulphur dioxide, part of the sulphur dioxide and oxygen combine forming sulphur trioxide, this being apparently due to the "surface action" of the oxide. The extent of this "surface action" varies with the nature and physical conditions of each oxide. No sulphur trioxide was ever found unless a simultaneous absorption of sulphur dioxide occurred ; when manganese peroxide and sulphur dioxide, dried by phosphorus pentoxide, were brought together, no absorption took place, nor was any sulphur trioxide produced on the addition of dried oxygen.

If a mixture of dried sulphur dioxide and oxygen be passed over well-dried platinized pumice heated to 400–450°, very little sulphur trioxide is formed, and the drier the materials the less is the combination.—*Proc. Chem. Soc.*, p. 41, 1900.

4. *Determination of Radicles in Carbon Compounds.* By Dr. H. Meyer. Authorized translation by J. Bishop Tingle, Ph.D. 12mo, pp. x, 133. New York, 1899. (John Wiley & Sons.)—Dr. Tingle has done a good service in translating into

English Dr. Meyer's excellent "Anleitung zur quantitativen Bestimmung der organischen Atomgruppen." The quantitative side of organic chemistry, too often neglected in the laboratory, must receive a new impulse from this little book, and so must help forward investigation. G. F. B.

5. *The reflective power of metals and metallic deposits on glass surfaces.*—E. Hagen and H. Rubens have investigated this subject for wave lengths from 450 μ to 700 $\mu\mu$. The interesting conclusion is drawn, from the long list of substances examined, that the reflective power of pure metals, in general, increases with increasing wave-length. This fact appears very strongly in the case of gold and copper. Both metals show a very small reflective power for violet and blue light; while for the red rays of wave-length 700 $\mu\mu$ the reflective power of gold is as great as that of silver. The behavior of the various kinds of speculum metal was also considered. The mirrors employed by Rosse, Brashear and Schröder, which consist essentially of a mixture of copper and tin, possess essentially the same reflecting power, varying from 62 per cent at 450 μ to 68 per cent at 700 $\mu\mu$. The admixture of a small portion of nickel (in the case of the speculum metal of Brandes and Schünemann) lowers somewhat the reflecting power. The metal of Ludwig Mach, consisting of aluminum and magnesium in varying proportions, has a reflecting power between the same limits of wave-lengths of about 83 per cent to 83·4 per cent. Its reflecting power, therefore, appears to be independent of length of waves.—*Ann. der Physik*, No. 2, 1900, pp. 352–375. J. T.

6. *A Vacuum Electroscope.*—It has generally been assumed that a vacuum does not conduct electricity, and that electrostatic induction takes place in a highly rarified medium. H. Pflaum seeks to show the truth of this assumption by direct experiment. With a highly exhausted vessel he shows that electrostatic effects occur to a high degree, and that no luminosity could be detected under powerful inductive action. The vacuum therefore appeared to act like a perfect insulator.—*Ann. der Physik*, No. 2, 1900, pp. 290–293. J. T.

7. *Rapid spark discharges.*—An investigation in this subject by H. T. Simon is of interest in view of photographs of lightning which show successive discharges passing over parallel paths. The experiments were made with the Wehvelt interrupter. It was found that a spark follows the same path as a preceding one if the interval between the two does not exceed 0·0028 second. If this interval is larger the spark follows a new zigzag path. This time-interval appears to be independent of the length of the spark gap and of the material of the terminals.—*Gesellsch. Wiss. Göttingen*, 1899, pp. 183–186. J. T.

8. *The discharge of Electricity through Argon and Helium.*—R. J. Strutt, of Trinity College, Cambridge, has made some interesting experiments on this subject and reaches the following conclusions :

"The peculiar interest of the gases argon and helium is in their monatomic characters. The view now generally taken is that the electric discharge is conveyed in all cases by ions, these ions being produced by a dissociation process of some kind. If this be admitted there can be no escape from the conclusion that the ions of monatomic gases are split up into something smaller. The above experiments make it sufficiently clear, I think, that these gases convey the discharge in a normal manner. If the potential-fall at the cathode is a measure of the energy expended in the ionization of the gas when effected by an electric field, the experiments show that the ionization of argon and helium is somewhat more easily effected than that of other gases. There are other reasons for thinking that the atomicity of an elementary gas is not an important feature in its facility of ionization. Thus mercury vapor was found by Thomson and Rutherford to conduct much more freely than air under the influence of the X-rays. Helium, on the other hand, conducts only about half as well as air.—*Phil. Mag.*, March, 1900, pp. 293–307. J. T.

9. *An Experimental Research on Some Standards of Light;* by J. E. Petavel.—The author has carried on, during the past three years, an extensive series of experiments, having as their object the investigation of the most valuable light-standards of the incandescent type. The requirements for a practical standard are summarized as follows: (1) The standard must remain constant for long as well as short periods. (2) It should be reproducible. (3) The light emitted should be as nearly as possible of the same spectral composition as that of the chief artificial lights now in common use.

Experiments with the electric arc have led the author to the following conclusions:

(1.) The intrinsic brilliancy of the crater of a silent arc is about 147 candle-power per square millimeter.

(2.) Even when the most favorable conditions are selected, and the intensity of current and the length of the arc are maintained constant, it is difficult to obtain consistent results. variations of over 5 per cent. being by no means unfrequent, The crater of the arc does not, therefore, possess the qualities required of a standard.

(3.) Variations in the size of the carbons, in the intensity and density of the current, in the length of the arc, and in the total power expended (as long as the arc is kept silent,) will not cause the intrinsic brilliancy to vary more than 10 per cent. on either side of the mean.

(4.) No sensible variation in the intrinsic brilliancy, and therefore in the temperature of the crater, is produced by placing the carbons in an enclosure maintained at over 900° C.

The experiments confirm the theory that the crater of the arc is at the temperature of volatilization of carbon.

The Lummer and Kurlbaum incandescent platinum standard was also made the object of careful trials, but the result was

reached that it does not possess the qualities required of a primary standard, although under certain conditions it may be of great value as a standard of reference.

Passing to the subject of the molten platinum standard, first proposed by J. Violle in 1881, the author concludes, after experimenting upon the fusion of platinum by an electric current and with the oxyhydrogen blowpipe, that the latter leads to the best results if the platinum selected is chemically pure, the crucible is made of pure lime, the hydrogen contains no hydrocarbons, and the gases are burnt in the ratio of four volumes of hydrogen to three of oxygen. The temperature of the flame, if the last condition is observed, is but little above the melting point of platinum, and the metal is not essentially superheated. A detailed account is given of the methods employed for attaining a high degree of accuracy, particularly in the photometric parts of the work, and a series of tables show the results reached; for details of these reference must be made to the original paper.

The final conclusion is important, viz., that under standard conditions the probable variation in the light emitted by molten platinum is not above 1 per cent, and with more perfect apparatus and somewhat better experimental conditions, the accuracy could be increased beyond this point. It is not impossible, even, that the accuracy of the platinum standard may attain to, or even surpass, the limit fixed by physiological conditions.—*Proc. Roy. Soc.*, lxv, pp. 469–503.

10. *A Text-Book of Physics;* by W. Watson, Assist. Professor of Physics at the Royal College of Science, London. Pp. xxii, 896. London 1899 (Longmans, Green & Co.).—The varied wants of different teachers of Physics have led to the publication of a long series of text-books, many of them of a high degree of excellence, though no two cover just the same field. Of this latest addition to the series it is possible to speak in terms of decided commendation. Many teachers, among those who have not written book for their own classes, are likely to find that it more nearly fills their wants than any one of its predecessors. It gives a clear, systematic and thorough presentation of the whole subject and from a rather advanced standpoint, though it does not assume the knowledge of more than the ordinary methods of mathematics.

The book is not an easy one for a large class of elementary students, certain portions, for instance the chapters on electricity, being rather difficult,—more so in fact than those on light, where the methods of geometrical optics are pretty closely adhered to. In the former case, the author seems to go almost too far in his admirable plan not to dwell too much upon the experimental side of the subject. Some students will wish that the printer had been a little more liberal in the use of italics, as it is a help to one approaching the subject for the first time to have the essential subjects and principles discussed brought at once clearly before the eye. It is also rather to be regretted that the pub-

lishers did not think it worth while to take a little more pains with the illustrations, which are not up to the level of the typographical work. Future printings will give the author an opportunity to correct an occasional slip, as for example, when he dates the first recognition of the phenomena of statical electricity from "about the commencement of the Christian era" instead of six hundred years before. One cannot but surmise that he may have been misled by a typographical blunder in recent editions of another well-known text-book.

II. Geology and Mineralogy.

1. *Geology of the Yellowstone National Park; Descriptive Geology, Petrography and Paleontology;* by Messrs. Hague, Iddings, Weed, Walcott, Girty, Stanton and Knowlton (Monograph xxxii, Part ii, U. S. Geol. Surv., 4to, pp. 791, Plates 121). Washington, 1899.—There is probably no area of equal size in this country to the geology of which so much popular interest attaches as the Yellowstone National Park. The very features to which it owes its existence as such, are those dependent upon its geological formation, and as year by year it is seen by a greater number of visitors and becomes better known, the Park serves to awaken interest not only in its own geology but in the science in general.

The appearance, then, of this great monograph containing the reports of the various well known specialists who have assumed different departments of the field of research, opened up by the exhaustive studies and collections made in the Park, will be greeted with more than ordinary attention. We regret that our space does not permit us to give the extended review that the work deserves, but that we must content ourselves with a brief notice of the more important portions of its contents.

The volume opens with a descriptive account by Iddings and Weed of the Gallatin Range and its geology. The sedimentary rocks ranging from the Cambrian upward to the Laramie have been uplifted, faulted, and intruded by igneous magmas in large laccolithic bodies, dikes and sheets. Erosion has laid bare the structures and later glaciation has modified the topography. The petrography of the igneous rocks is then described by Iddings, who shows that they are mostly fine-grained, porphyritic rocks of andesitic character. An occurrence of differentiation in an intrusive sheet by the settling of augite crystals is given. The third chapter is a description by Iddings of Electric Peak and Sepulchre Mountain and is practically a reprint of a former article noticed in this Journal (vol. xliv, p. 429, 1892). They are regarded as parts of a dissected volcano.

The northern end of the Teton Range projects into the Park and its geology is described by Weed and Iddings. It consists of a nucleus of gneisses and schists covered with Paleozoic and Mesozoic strata flexed in an anticline with northward dipping

axis and somewhat faulted. Upon these greatly eroded strata, basic breccias were piled up, eroded in turn and then came vast flows of rhyolite, which now form part of the Park Plateau and hide the northern end of the range.

In the fifth chapter Hague describes the geology of a mountainous area in the southern part of the Park, which consists of a number of ridges of northwest and southeast trend, mostly composed of Mesozoic rocks. The irregular outline of these mountains is due to the rhyolites of the Park Plateau that abut against the upturned beds. A few exposures of dacite occur in this area surrounded by rhyolite which they apparently antedate. Hot spring areas and localities of fossil flora are described. An interesting and important feature is the discovery of the former outlet of the Yellowstone Lake in Outlet Cañon through Chicken Ridge, which in former times served to drain the lake waters westward into the Snake River and so into the Pacific, instead of into Atlantic waters as at present. The chapter closes with a description of Two-Ocean Plateau, forming part of the Absaroka Range and composed of volcanic breccias and silts.

The southern end of the Snowy Range is described by Weed. It forms the northeast corner of the Park and its plateau-like summit of crystalline rocks is flanked by Paleozoic sediments which dip southward toward the Park. Detailed sections of these sediments are given. The highest peaks, as well as considerable areas, are formed by andesitic breccias lying on the Paleozoic rocks.

In Chapter VII, Iddings describes the Miocene volcano of Crandall basin, which was built up on eroded Paleozoic strata and earlier lava flows. It consisted of andesitic breccias topped by basalt flows and cut by dikes radiating from the central conduit, which was finally filled with magma; this became a mass of granular rock varying from gabbro to diorite and in part monzonite-like in character. In the outer flanks of the great volcano the breccias were fine and well-bedded; near the core they are coarse and chaotic. Comparison with modern cones of equal size like Etna shows the volcano rose over 13,000 feet above the Paleozoic floor. It is now thoroughly dissected by erosion and its interior laid open.

In the four following chapters Iddings describes the petrography of the types of igneous rocks found in the Park, the various kinds of andesites and andesitic breccias that so largely make up the Absaroka Range, the rhyolites which compose the great plateau, the basalts and certain rocks of peculiar composition found as dikes and small flows and classified as absarokites, banatites and shoshonites. These descriptions include in essence the former memoirs of the author on the rhyolite and glass of Obsidian Cliff (7th Ann. Rep. U. S. Geol. Surv., 1888, pp. 249–295) and on the peculiar dikes and flows (Jour. of Geol., 1895, p. 935).

The latter half of the volume is devoted to the Paleontology of the Park area and consists of three chapters, the Paleozoic fossils, the Mesozoic invertebrates, and the Mesozoic and Tertiary flora.

The Paleozoic sediments, clearly recognizable by their fossil contents, belong to the Cambrian, Devonian, and Lower Carboniferous terranes. The Cambrian fauna of about thirty species is described by the Director of the Survey, Charles D. Walcott. Several of the species are new to science, and one new genus, *Haguia*, is referred to a primitive type of *Archæocyathinæ.*

The Devonian and Lower Carboniferous collections are discussed by Dr. G. H. Girty. The Devonian fauna is a meager one, and the fossils are generally poorly preserved. The Madison limestone, representing probably the major portion of the Mississippian with Kinderhook affinities, contains a much richer and more varied fauna of seventy-nine species.

The Mesozoic invertebrates were studied by T. W. Stanton. Thirty-one species are recognized from the Cretaceous, forty-six from the Jurassic, and one from beds of supposed Triassic age. The Jurassic fauna is the most important, and in number of species it compares favorably with the Jurassic of other parts of the Rocky Mountain region.

The fossil flora of the Park by F. H. Knowlton forms the subject of the last chapter, and is an important geological and paleobotanical contribution. Eighteen species represent the Park Mesozoic flora as contained in the Laramie sandstones of the Cretaceous, no plants having yet been found from the Jura or Trias.

The chief points of geological interest arise from the fact that all the Tertiary plant remains occur in beds of volcanic origin, thus giving direct evidence of the age and period of some of the great igneous activities which are responsible for most of the marvelous geological phenomena of this region.

The older series of lavas, as determined by the geologists, have been designated as the early acid breccias and flows, while the younger series are known as the early basic breccias and flows. Both of these series contain ash beds probably deposited as mud flows. In these the plant remains have been preserved, each series being marked by different floral characteristics, with a subordinate intermediate flora in the upper early acid breccias.

The earliest flora, that of the early acid breccias, contains seventy-nine species, of which forty-two are new to science. Its affinities are shown to be with those of the Fort Union beds, though forms common to the Laramie, Green River, and Auriferous gravels are also present. The intermediate flora is related to that of the younger or basic series. The third flora, the one occurring in the early basic breccias, embraces seventy species, and is shown to have its closest relationships with the Auriferous gravels of California, now referred to the Upper Miocene Tertiary.

The noted fossil forests of the Yellowstone National Park form the subject of a separate section. They are undoubtedly the

most remarkable objects of their kind thus far discovered in any part of the world. They occupy more extensive areas than any other aggregation of fossil trees yet described, and, moreover, they are unique in retaining the trees standing upright in the exact positions in which they grew originally. The trees were largely conifers, and some of them attained gigantic proportions, though in the main the trunks will not average more than from two to five feet in diameter. Nearly all the localities show a succession of these silicified forests lying one above another. The primitive forest was buried under volcanic débris, probably at the time of an eruption, and gradually petrified by waters charged with silica. After a period of quiet, a second forest gained a foothold and flourished above the first. In its turn, the second was buried and silicified as the first had been. At the locality known as Fossil Forest, on Amethyst Mountain, this process of successive burial and renewal of the Tertiary forests was repeated through two thousand feet of volcanic material, and no less than fifteen forests were entombed. The mode of illustrating the species of trees constituting the fossil forests is somewhat novel, consisting of the usual photographs showing the minute structure of the wood, and others illustrating the fossil trunks as they appear in the Park, protruding from the volcanic deposits, and sometimes standing alongside of trees belonging to the existing flora.

In a section devoted to the biological consideration of the Tertiary flora of the Park many interesting comparisons are made with the present flora of the same region, and the deduction is made that then as now the coniferous type of tree predominated, though there was much greater variety during Tertiary time than now. The climate also was considerably warmer and approximated the conditions at present existing in Virginia.

L. V. P. and C. E. B.

2. *The Silurian Rocks of Britain.* Vol. I. *Scotland;* by B. N. PEACH and JOHN HORNE. *With Petrological Chapters and Notes;* by J. J. H. TEALL. Mem. Geol. Surv. United Kingdom, Vol. I, Plates I–XXVII, figs. 1–121, with map, pp. iii–xviii, and 1–749, 1899.—The present publication, forming the first volume of the Monographs of the Geological Survey of the United Kingdom, on the Silurian Rocks of Great Britain and Ireland, is devoted to the Silurian formations of Scotland. It presents a detailed summary of all that is known up to the present time regarding these early records of the geological history of the country. This volume is a continuation, in style and size, of the "Memoirs of the Geological Survey of Great Britain and of the Museum of Economic Geology in London;" the first volume of which was published in 1846, and Volume III, 1st edition, was published in 1866, by the Director-General Murchison, and a second edition of it appeared in 1881, by Director Ramsay. Many new facts are reported worthy of special notice, to some of which we hope to give attention in a future issue.

This volume is of more than ordinary interest, and worthily stands as the first of a new series of publications, the Monographs of the Geological Survey. The researches reported in it combine stratigraphical, petrographical and paleontological studies of the most thorough kind, of a very complex series of rocks much disturbed by folding and faulting and with igneous intrusions. Messrs. Peach and Horne, the chief authors of the volume, began the study of the southern uplands geology in 1888, having as a clue for the interpretation of the stratigraphy the results of Professor Lapworth's studies, particularly the carefully established succession of graptolites. They make special reference to the value of Professor Lapworth's results as well as his method of investigation, at the close of the second chapter. Mr. J. J. H. Teall contributes valuable chapters on the petrography of the igneous rocks, the granite masses, and on contact metamorphism. Several specialists, both within and outside the Survey, contribute both assistance and advice. Not least among these is Mrs. Robert Gray, whose superb collection of 30,000 specimens of the Silurian fossils of the Girvan district was first placed at the service of Messrs. Nicholson, Etheridge and Lapworth; it was again at the disposal of the Survey; and in the Appendix is published a list of the fossils with their range and distribution, prepared by Mrs. Gray.

The value of the report is heightened for the general reader by the chapter (II) giving a concise, but full, history of previous researches among the Silurian rocks of the south of Scotland, beginning with Hutton in 1795. The recapitulation of the results of the investigations of the Geological Survey in the southern uplands will indicate some of the more important problems here discussed in detail:

"1. The occurrence of a series of Arenig volcanic and plutonic rocks on various anticlines over an area of about 1500 square miles.

"2. The existence of a well-marked band of radiolarian cherts and mudstones, overlying the foregoing volcanic series, which has been traced over a part of the uplands measuring about 2000 square miles.

"3. The main band of radiolarian chert and mudstone, though about 70 feet thick, represents the succession of deposits which, elsewhere in Britain, intervene between the Middle Arenig and uppermost Llandeilo strata.

"4. The occurrence at various localities over a limited area of volcanic rocks of Llandeilo and Caradoc age.

"5. During the examination of the various black shale outcrops throughout the uplands, a great amount of detailed evidence has been obtained, confirming the order of succession established by Professor Lapworth, and the lateral variation of the strata between Moffat and Girvan.

"6. The inclusion of the Downtonian strata of Lanarkshire and the Pentland Hills in the Silurian system, owing to the discovery

of fishes, eurypterids, etc., resembling those occurring in the Ludlow rocks of Lanarkshire and other regions." W.

3. *Lower Cambrian Terrane in the Atlantic Province;* by CHARLES D. WALCOTT. Proceedings of the Washington Academy of Science, Vol. I, Plates XXII–XXVI, figs. 9–11, pp. 301–339, 1900.—The study of the New Brunswick and Newfoundland lowest Paleozoic rocks has led Mr. G. F. Matthew to the establishment of a basal or Etcheminian series of rocks of supposed pre-Cambrian age, and the adoption by him of a classification which recognized only two divisions of the Cambrian, an Upper Cambrian (Potsdam with Olenus fauna) and a "Lower" Cambrian (with the Paradoxides fauna), equivalent to the Middle Cambrian, or Acadian, but including the subjacent Protolenus fauna, which he regarded as equivalent to the Olenellus fauna of the Georgian or Lower Cambrian.

Mr. Walcott, after exhaustive study of the original sections upon which Mr. Matthew's interpretations were made, both in Newfoundland and New Brunswick, establishes the following conclusions:

"(*a*) The 'Etcheminian' terrane of Matthew is of Lower Cambrian age.

"(*b*) The Olenellus fauna is older than the Paradoxides and Protolenus faunas of the Middle Cambrian.

"(*c*) The Cambrian section of the Atlantic Province of North America includes the Lower, Middle, and Upper Cambrian divisions as defined by me in 1891."

These are supported by the following facts:

"(*a*) That the Olenellus fauna in Newfoundland occurs 420 feet beneath the Paradoxides fauna, in the heart of the Lower Cambrian 'Etcheminian.'

"(*b*) That fragments of the fauna are found 460–480 feet below the Protolenus fauna in the 'Etcheminian' of the Hanford Brook section of New Brunswick.

"(*c*) That in the undisturbed, unbroken Highland Range section of Nevada the Olenellus fauna is 4450 feet below the Upper Cambrian fauna, and that the Olenoides (Dorypyge fauna of Matthew) is 3000 feet below the horizon of the Upper Cambrian fauna and 1450 feet above the horizon of the *Olenellus gilberti* fauna.

"(*d*) That in the southern Appalachians the Olenellus fauna occurs more than 7000 feet below the highest Cambrian fauna known in that region, and fully 2000 feet below a typical Olenoides fauna." W.

4. *Geological Survey of Canada*, GEORGE M. DAWSON, Director.—Accompanying three sheets of a revised edition of the Geological map of the Sidney Coal field (sheets 133, 134, and 135; new numbers, 652, 653, and 654), the Survey publishes a Descriptive note on the Sydney Coal field, Cape Breton, Nova Scotia (No. 685). The Barachios slates are reported as Cambrian (from Etcheminian to Lingula Flags), according to determi-

nations of Dr. G. F. Matthew. The "Carboniferous conglomerate series," lying below the Carboniferous limestone series, was formerly correlated with the Devonian or Old Red sandstone of England. The Carboniferous limestone series underlying the Millstone grit occasionally holds marine fossils. W.

5. *Das geotektonische Problem der Glarner Alpen;* von A. ROTHPLETZ. Pp. 251. Atlas of x plates and one colored map. Jena, 1898 (Fischer).—The complicated structures of the Glarner Alps, southeast of Zurich, have been explained as the result of a remarkable pair of folds whose crests lean towards each other from the north and south, covering a pouch-like trough; Heim being the chief exponent of this view in his celebrated "Untersuchungen ueber den Mechanismus der Gebirgsbildung" (1878). For some fifteen years past, Rothpletz of Munich has been studying this difficult region, and his results contradict the conclusions previously announced. His latest essay, of title as above, leads to the following summary: The undermost or basal mountain mass consists of a series of closed folds of all formations from gneiss to Oligocene; the folds lean over to the northwest. This basal mass has been completely covered by overthrusts, and is to-day laid bare only in deeply eroded valleys. The first overthrust, a deformed mass of all formations from gneiss to Eocene, was driven over the basal mass from the east. Two later overthrusts were shoved on from the northwest. The overthrust masses have been splintered and wedged; the thrust surfaces have been severely scoured; the composite mass has been deeply eroded, and the overthrusts here mentioned as single masses are to-day dissevered. The sources of the overthrust masses lies outside of the field of study and must be searched for by further exploration. Longitudinal and cross faults have disturbed the composite structure. Some of the cross faults are associated with valleys; those of the Linththal in particular are stated to have produced a *graben*-like depression by which the direction, breadth and depth of the existing valley have been determined.

At this distance from a field in which controversy has been ardently carried on by local experts, it is not advisable to attempt a judgment on so difficult a problem as the structure of the Glarner Alps. One observer says that his criticisms of earlier work have fallen on deaf ears; an earlier observer replies that his critic has made inaccurate observations. While deprecating the polemic thus aroused, we may hope that many will follow the example of one of these geologists who announces that he will for the present lay down his pen and take up his walking stick, with the promise of reporting further observations and conclusions at a later time. W. M. D.

6. *Ore Deposits of the United States and Canada;* by J. F. KEMP; 3d ed., 8vo, pp. 481. New York City, 1900. (The Scientific Pub. Co.)—The great development of mineral resources during recent years has resulted not only in opening new, extensive and varied fields to industry, but has afforded

excellent opportunity for the scientific study of ore-deposits from both a practical and theoretical standpoint. So rapid has been the advance along this line, especially in the United States, that hitherto the student has found the text-books on the subject rapidly becoming antiquated, and unless possessed of considerable time and facilities for extensive reading of the literature, has been compelled to labor at a disadvantage.

Professor Kemp has succeeded admirably in filling this deficiency in the literature of this subject, in the volume before us. In this he has to a large extent rewritten the former edition of his book on ore-deposits, and made very considerable additions of new material. It is a work the value of which will be appreciated by all who have occasion to use it, containing, as it does, a concise yet comprehensive and thoroughly up-to-date description and consideration of the ore-deposits of the United States and Canada.

Part I is introductory in its nature, its chapters being devoted to such brief considerations of geology—of the formation of cavities for the reception of ores; of the minerals forming ores; of the facts and theories concerning the methods of their deposition; of the structure of veins and the classification of ore-deposits—as are necessary for an intelligent reading of the descriptions of Part II. The author has, and we think wisely, included here only a single broad scheme of classification based largely on origin, and in accordance with the results of the most recent investigation. The presentation and discussion of the numerous other classifications, which if included in the text might lead to confusion, are referred to the Appendix.

Part II deals directly with the principal ore-deposits themselves, classed under the heads of the appropriate metals. In presenting the theories relating to the genesis of the ores, excellent judgment has been shown in giving only such as have a substantial basis in observed facts and in omitting all those more or less fanciful theories which so often burden the literature on this subject. The descriptions in the text are supplemented by excellent half-tone engravings, maps and diagrams taken from various sources. Especial mention might be made of those illustrating the occurrence of the Lake Superior iron ores, the mineral lodes of Butte City, Mont., and those of Alaska.

The full lists of references to the literature on ore-deposits, distributed throughout the book, will certainly be of great value to anyone desiring a more thorough and extended knowledge of this subject. C. H. W.

7. *The Ward-Coonley Collection of Meteorites.* Pp. 100, plates VI. Chicago, 1900.—The collection of meteorites described in this catalogue has been brought together by Professor H. A. Ward and includes some 424 independent occurrences. It thus ranks as one of the very large collections of the world. It is also remarkable in the total weight as too in the size of the individual specimens. The aggregate weight amounts to 1400

kilos (over 3,000 pounds), while the average weight of each kind is 3·3 kilos ($7\frac{1}{4}$ pounds). Each specimen is described and a series of six plates, most of these of etched plates, adds to the value of the volume.

III. Miscellaneous Scientific Intelligence.

1. *Earthquakes in Japan.*—A recent number of the Journal of the College of Science of Tokyo (vol. xi, pt. iv) contains the Earthquake Investigation Committee catalogue of Japanese earthquakes since the earliest times, by the late Prof. Sekiya. This report is discussed in the article following by Prof. Omori, with respect to the number of earthquakes, their chronological distribution, variation with the season, and other points. The total number of *destructive* earthquakes in Japan from the year 416 A. D. to the end of 1898 is 222. Of these, but few were recorded in the fifth, sixth, and seventh centuries, probably because of the imperfection of historical records in those earlier times. Beginning, however, with December 678, there are recorded 220 destructive earthquakes in the interval of 1220 years to the end of 1898, or one for about every five and a-half years. Were the records of earlier parts of this period more complete, this interval would undoubtedly be shorter. In the interval of nearly 300 years, from the beginning of the seventh century to the end of 1898, there were 108 destructive earthquakes in Japan; from which it is concluded that one part or another of Japan (except Formosa) is likely to be visited, on the average, once in nearly two and a-half to three years.

With respect to the distribution through the year, it is found that of 216 destructive earthquakes, 48 occurred in the spring, 74 in the summer, 49 in the autumn, and 45 in the winter. The maximum monthly number of 32 occurred in August, and the minimum of 10 in January. The frequency of ordinary small shocks, however, is found to be a minimum in the months of June, July, August, and September; in other words, just the reverse of the severe earthquakes. This fact, however, admits of explanation, as shown by the author, since the constant occurrence of small earthquakes in an unstable country like Japan may be regarded as maintaining the region in a normal safe condition, thereby preventing any abnormal condition of stress in the earth's crust. Their non-occurrence, however, may cause an accumulation of stress, facilitating the occurrence of destructive seismic disturbances.

Discussing graphically the distribution of the earthquakes in Japan from the eighth century on, it is found that this is not uniform but rather in groups; in other words, that destructive earthquakes, while sometimes happening isolated, tend to occur in groups in epochs of maximum frequency. The geographical distribution of the earthquakes in the different parts of the country is also minutely discussed.

2. *On the Propagation of Earthquake Motion to great Dis-*

tances; by R. D. Oldham, Geological Survey of India. (Abstract.)—When preparing a report on the great Indian earthquake of 12th June, 1897, the author noticed that the European records of this earthquake showed a phase of increased disturbance in what are commonly called the preliminary tremors, making, with the great undulations, three phases of motion. He suggested that these three phases represented the arrival of (1) the condensational, (2) the distortional waves traveling through the earth, and (3) surface undulations traveling round the earth. The present paper is an attempt to verify these suggestions by a comparison with other earthquakes.

For this purpose a selection has been made from the published records of those earthquakes which fulfil the conditions (1) that the place of origin shall be known within 1° of arc, (2) that the time of origin shall be known within a limit of error of one minute, (3) that there shall be a sufficient number of records, distant more than 20° of arc from the origin, to serve as a check on each other. Eleven distinct shocks, representing seven great earthquakes, are found to satisfy these conditions, and in every case the same three-phase character as was recognized in the earthquake of 12th June, 1897, is found. A comparison of time intervals and apparent rates of propagation shows that the coincidence is not accidental, but represents the separation of three distinct types of wave motion having different rates of propagation.

On plotting the records it is found that the time curves of the first two phases form curved lines, indicating an increase of apparent velocity with distance from the origin, such that, applying Rudzki's investigation, the wave motion represented by these two phases must have traveled through the earth, along curved wave paths, convex towards the center of the earth, and with a rate of propagation which increases with the distance from the surface. On continuing these curves, by extrapolation, to the origin, they give rates of propagation in very fair concordance with the rates of propagation of condensational and distortional plane waves which may be expected to obtain in continuous rock at some distance from the surface of the earth.

The waves of the third phase show no such increase of rate of propagation with distance from the origin. The rate of propagation is uniform at all distances; from which it is concluded that the great undulations of the third phase are surface waves, traveling with a uniform rate of propagation round the surface of the earth. It is also found that the waves of this phase set up by great earthquakes travel faster than those set up by lesser ones, and from this it is concluded that the rate of propagation of these waves is in some way a function of their size, thus affording a confirmation of Lord Kelvin's suggestion that their propagation is in part gravitational.

The general conclusion is that in the complete record of a distant earthquake, three distinct types of wave motion can be

recognized: (1) condensational, and (2) distortional plane waves, traveling by brachi-stochronic paths through the earth, and (3) elastic, or gravitational elastic, surface waves, traveling round the surface of the earth. The records are, however, often incomplete by the omission of the first or the first and second of these phases, and the widely divergent estimates of the apparent rate of propagation of the preliminary tremors are largely due to this.—*Proc. Roy. Soc.*, lxvi, 2, 1900.

3. *On Earthquake Sounds.*—Dr. C. DAVISON closes an interesting paper in a recent number of the Philosophical Magazine with the following discussion as to the *origin of earthquake sounds:* "In any earthquake there are generally three well-defined stages of motion—the preliminary tremor, the principal portion, and the end portion. In the first, the characteristic movements are small in amplitude and short in period; the second and most active part of the disturbance consists chiefly of vibrations of larger amplitude and longer period; and these are followed by the feeble movements which constitute the end portion. Slow undulations, with a period of about one-half to two seconds, may, however, be present in all three stages; while the ripples, with a period of one-tenth of a second or more, may be superposed on the slow undulations in the second and third stages as well as in the first. The average period of the ripples, it is important to notice, is slightly greater during the principal portion than during the other two stages.

During the earlier part of the movement there is a distinct increase in the period of the vibrations; and this has led some seismologists (all at the time living in Japan) to suggest that the first recorded tremors may be the successors of those which produce the preliminary earthquake-sound. The observations of British earthquakes show, however, that the sound-vibrations are not confined to the earlier stage, but that, like the ripples, they are also superposed on the slow undulations which form the main feature of the principal and end portions of an earthquake.

Some of the phenomena of earthquake-sounds, as we have seen, are due to the neighborhood of the sound to the varying lower limit of audibility. There are others, such as the time and space-relations of the sound and shock, for which a different explanation is required, and whose origin is of a geological rather than a physical character.

The theory which follows is based on the supposition that the majority of non-volcanic earthquakes are due to the gradual, but intermittent, growth of faults; the immediate cause of the disturbance being the friction produced by the slipping and rubbing of one of the adjoining rock-masses over and against the other.*

* The principal facts in favour of the fault-slip theory are:—(1) The elongated forms of the isoseismal lines, the longer axes of which in any district are, as a rule, either parallel or perpendicular to one another, and parallel, or nearly so, to the chief lines of fault; (2) the formation of fault-scarps concurrently with violent earthquakes; (3) the impossibility of a great fault growing otherwise than by an almost infinite number of slips; and (4) the enormous excess of the number of earthquakes over the number of faults in any one district.

A fault-slip does not of necessity take place concurrently all over the focus or instantaneouly at any one point of it. But, as a general rule, it certainly occupies a very short interval of time, and at places near the epicentre the duration of the sensible part of an earthquake must be mainly due to the size of the focus and the finite velocity of the earth-waves.

The seismic focus is practically a surface inclined to the horizon, and is often of great length in a horizontal direction. In its simplest form there will be a central region of the fault-surface where the relative displacement of the two rock-masses is a maximum, and this will be surrounded by a region in which the relative displacement is small, and gradually dies away towards the edges. As the vibrations of great amplitude are also of long period, we may consider that from all parts of the focus there start together vibrations of various amplitude and period, the large and slow undulations coming mostly from the central region, and the small and rapid vibrations of those which bound it. It is, I believe, from these marginal regions, and especially from the upper and lateral margins, that the more sensible sound-vibrations chiefly come. I will now endeavour to show how the phenomena of earthquake-sounds can be explained on this theory.

If there is no discontinuity in period between the large vibrations which come from the center of the area and the sound-vibrations from the focal margins, it is evident that among the vibrations must be included those which produce the deepest sound that can be heard by the human ear. The rumbling character of the sound may be due partly to its neighbourhood to the lower limit of audibility, partly, no doubt, to irregularities in the fault-surface producing local vibrations in the initial disturbance. To the latter cause may also be owing the intermittent sounds heard by some observers.

But whether there be any slight fluctuations in amplitude and period, or not, it is evident that the average intensity of the sound must gradually increase until the shock is felt; and as soon as it is over, or nearly over, must gradually die away. At the same time the greater amplitude of the vibrations from near the central part of the focus will render audible vibrations of longer period than those which come from the margins; and thus the depth of the sound will increase and decrease with the intensities of the sound and shock. Especially will this be the case with the vibrations from the neighbourhood of that part of the focus where the initial amplitude is greatest; and the strongest vibrations and loud explosive crashes audible to some persons should therefore be observed concurrently.

Similar reasoning leads to the conclusion that the intensity of the sound should increase with that of the shock in different earthquakes, and that the sound should be deeper with strong shocks than with weak ones. But while the marginal vibrations are limited in period and amplitude, those from the central parts of the focus have a much wider range. With very weak shocks the

sound should be the most prominent feature; with very strong ones the sound, though actually louder, should be relativelv insignificant; and when, as in the Hereford earthquake, the earthquake consists of two distinct parts, the two shocks may differ widely in intensity, while the accompanying sounds may be almost equally loud.

With observers of given average auditory powers, the magnitude of the sound-area depends on the limited strength of the marginal vibrations, and on the dimensions of the seismic focus, and therefore of its marginal regions. The magnitude of the disturbed area depends partly on the size of the focus, chiefly perhaps on the initial intensity of the vibrations from its central portion. While the dimensions of the sound-area should generally increase with those of the disturbed area, it is evident that they should not increase in the same ratio. With very strong shocks, the sound-area should be a comparatively small district surrounding the epicentre. With very slight ones, the marginal regions would be so great compared with the central portion of the focus, that the sound-area might overlap the disturbed area. In the limit, the central portion of the focus would vanish, and an earth-sound would be the only result sensible to human beings.*

Several of the phenomena of earthquake-sounds depend on the superficial form and inclined position of the focus, and on the fact that the most sensible sound-vibrations come from the upper and lateral margins. The isacoustic lines and the boundary of the sound-area should not be concentric with the isoseismal lines. Relatively to the latter the sound-area will be shifted towards the fault-line, and also in a direction parallel to it, if one lateral margin should predominate over the other.

The time-relations of the sound and shock remain to be considered. The sound-vibrations from the margin nearest to the observer should be heard before the shock begins, those from the upper margin, and possibly from parts of the central portion, during the progress of the shock, and those from the furthest margin after the shock ends. Moreover, the sound-vibrations from the nearer lateral margin will be of greater intensity than those from the further one; and thus the fore-sound should be more generally heard than the after-sound, and with Japanese and some other observers should be the only one perceptible. The percentage of observations of the after-sound should also diminish with the increasing distance from the origin; and the duration of the sound, especially near the epicentre, should be greater than that of the shock.

At places near the epicentre, and also at the places whose distances are great compared with the dimensions of the focus, the sound-vibrations which appear loudest will be those which origi-

* It has been suggested that the comparative smallness of the sound-area may be due to the more rapid extinction of the sound-vibrations; but the explanation is clearly incomplete, for it fails in the cases in which the sound-area overlaps the disturbed area.

nate near the central portions of the focus; and thus the epochs of maximum intensity of the sound and shock should coincide. If, however, the horizontal length of the nearer focal margin be considerable, the sound which seems loudest to observers at a moderate distance may come from or near that margin; for there is but little change in the initial intensity of sound-vibrations from the neighbourhood of the central portion. To observers who are situated near the continuation of the line of fault, the maximum epoch of the sound will therefore precede that of the shock; while to those who are near the minor axis of the isoseismals, the two epochs will approximately coincide."

4. *On the origin of Gulf Stream water;* by P. T. Cleve. (From the Öfver. Vet. Akad. Förhandlingar, 1899. No. 9. Stockholm.)—Hydrographers understand by "gulf-stream water" such water in the northern Atlantic as contains about 35, or rather more, p.m. of salt. The name indicates that it is supposed that such water is derived from the gulf-stream, or the surface-current, which runs from the Gulf of Mexico. The study of the geographical distribution of the plankton-organisms has convinced me that such a supposition is, at least for the greater bulk of gulf-stream water, erroneous and that the gulf-stream water comes into the northern Atlantic along the west coast of Africa and between the Azores and Europe. This is in direct opposition to all surface-currents, so it must be admitted that the gulf-stream water moves as an under-current. I know a number of plankton organisms, which all point to the above conclusion. Samples from the Benguela current, for which I am indebted to the kind assistance of Doctor Van Doesburgh on the Fregatte Atjeh of the Dutch Navy, make it more than probable that the gulf-stream water reaches the Atlantic round the Cape of Good Hope.

I have comprised under the name *styli-plankton* such organisms as inhabit the gulf-stream water of the hydrographers. The number of such forms, known to me at present, is very considerable, but I will here treat of the distribution of a smaller number only, selecting some of the typical species. Some of these styli-plankton organisms are confined exclusively, or nearly so, to the eastern Atlantic. Some have a very wide range of distribution and occur both in the eastern, western and northern Atlantic, or round the Sargasso Sea.

It will be found from the following data that such styli-plankton organisms as have a very wide range of distribution follow both the eastern side of the Atlantic, or along the coasts of Africa between the Azores and Europe, and the equatorial current towards South America into the Caribbean Sea, and thence the Antilles and Florida currents towards the Newfoundland banks and farther to about 45° to 50° N., where they seem to unite with those coming from the east Atlantic. They proceed then to the north, towards Iceland and the Färöe Channel, and a small number finally reach Spitzbergen. . . .

The species, whose distribution is discussed in detail, are as follows: *Corycæus rostratus*, *Clausocalanus arcuicornis*, *Acartii Clausii*, *Centropages typicus*, *Dictyocysta elegans*, *Undella candata*, *Chætoceros skeleton*, *Dactiosolen antarcticus*, *Challengeria xiphodon*. The author adds: "All the above data, which I could easily multiply, prove beyond doubt that the gulf-stream water, proceeding from the east of Africa towards the Azores and the European coast, expands above the 40° N. so far to the west as to approach the American coast. From 40° N. it advances to the north, to Iceland and the Färöe Channel. It turns in September to the north of Iceland. From the Färöe Channel it flows into the North Sea and, as will be shown further on, towards Spitzbergen.

In the following I will treat of some styli-plankton forms with a very wide range of distribution, in order to show that the styli-plankton also follows the South Equatorial current to S. America as well as into the Caribbean Sea, and the Antilles and Florida currents towards the north." . . .

Hear are included *Paracalanus parvus*, *Coscinodiscus* (*Planktoniella*) *Sol.*, *Rhizosolenia styliformis*. The author concludes: "The range of distribution of *Rhizosolenia styliformis* fairly indicates the area within which the styli-plankton occurs. Although of so wide a range it has been very rarely seen in the Sargasso Sea, round which the styli-plankton water occurs.

In March–May the styli-plankton extends along 50° N. from America to the English Channel. Already in April this area has advanced to 60° N., in June to Iceland. From that island it spreads on the east to the Shetlands, on the west to Greenland, where rare specimens follow the east Greenland current and arc conveyed in October into Davis Strait. Other specimens follow the current to the north of Iceland in September, others drift to Spitzbergen, where they already appear in August."

5. *Annals of the Astronomical Observatory of Harvard College*, EDWARD C. PICKERING Director.—The recent publications of this valuable series are as follows:

Volume XXXII, Part II, contains Visual Observations of the Moon and Planets, by William H. Pickering, carried on for the most part at the station near Arequipa. Volume XXXIII contains Miscellaneous Researches made during the years 1894–1899 by different observers; these include Photometric Observations of Asteroids, Observations of Variable Stars, Nebulæ, Comets, etc. Volume XLII, Part II, contains the Observations made at the Blue Hill Meteorological Observatory in 1897 and 1898, under the direction of A. Lawrence Rotch. These are concerned chiefly with Cloud Observations under varying conditions. Volume XLIV, Part I, contains a Photometric Revision of the Harvard Photometry during the years 1891–1894, by Edward C. Pickering.

6. *Publications of the Yerkes Observatory, University of Chicago.* Volume I, pp. 296. *A General Catalogue of 1290 Double Stars;* by S. W. BURNHAM. Chicago, 1900.—The appearance of

the first volume of the publications from the Yerkes Observatory is a notable event. It contains the catalogue of the double stars discovered by Prof. Burnham from 1871 to 1897, arranged in order of right ascension, with all the micrometrical measures of each pair. The Introduction contains a description of some of the instruments employed by Prof. Burnham, accompanied by a series of plates; one of these, the frontispiece, shows the great 40-inch Clark telescope of the Yerkes Observatory.

7. *La Géographie, Bulletin de la Société de Géographie.*—The Société de Géographie of Paris has inaugurated, with the opening of this year, a new journal called La Géographie, which is to be published on the 15th of each month; it will include in expanded form the formerly issued *Bulletin trimestriel* and *Comptes Rendus.* Each number will contain some eighty pages, large octavo, including original memoirs, a bulletin of geographical news, a bibliographical index, and a *compte rendu* of the meetings of the Society. It will be illustrated with plates and figures in the text. The members of the Society who are chiefly concerned in editing the new journal are Baron Hulot and M. Charles Rabot. Two numbers have already been received: these contain a series of interesting articles; thus, two papers by Gen. Gallieni upon Madagascar and its resources; an account of a trip across Corea by Marcel Monnier; results of the Belgian Antarctic expedition by E. Racovitza, and others of like value.

8. *Biological Laboratory of the Brooklyn Institute of Arts and Sciences.*—It is announced that the eleventh annual session of the Biological Laboratory of the Brooklyn Institute at Cold Spring Harbor, Long Island, will be held during the months of July and August, 1900. The regular class work will begin on Wednesday, July 4th, and continue for six weeks. The laboratory will be open for work from July 2d until August 25th. Investigators may make arrangements for using the laboratory from the middle of June until the middle of September, or later, if desirous of doing so.

The Director of the Laboratory is Prof. Charles B. Davenport of the University of Chicago. The course of instruction includes zoology with comparative anatomy, and embryology and botany with ecology and bacteriology; advantages are also offered to students in other directions. Those desiring further information are referred to the Director (Chicago) or to Prof. Franklin W. Hooper, 502 Fulton street, Brooklyn.

9. *Royal Academy of Sciences at Berlin.*—The 200th anniversary of the foundation of K. Akademie der Wissenschaften at Berlin was celebrated with appropriate ceremonies on the 20th of March. The following new foreign correspondents from the United States were appointed: Prof. J. Willard Gibbs of New Haven, Prof. Henry A. Rowland of Baltimore and Prof. William James of Cambridge.

La riduzione progressiva della variabilita e i suoi rapporti coll'estinzione e coll'origine delle specie, di Daniele Rosa, pp. 3–133, 1899.

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[FOURTH SERIES.]

ART. XXX.—*Notes on the Geology of the Bermudas*;* by A. E. VERRILL.

THE geology of the Bermudas, though simple, has attracted considerable attention and has been reported upon quite fully by several writers. (See page 339.) In this brief article I propose to give mainly the general conclusions arrived at by myself, from observations made at Bermuda during a visit to the islands in April and May of 1898, with a party of students from Yale University, made for the purpose of studying the fauna, as well as the geology.

In some respects my conclusions will be found to differ considerably from those of others who have written upon the subject. Though in the main my studies confirm the observations made by Professor W. N. Rice, Mr. A. Agassiz, and Professor Stevenson, yet, in my interpretations of the facts, I do not agree entirely with either of those writers. The differences are mostly in respect to special points, but yet in some cases they are of considerable significance.

It has been known for some years that the Bermudas are not coral islands, as they were formerly thought to be, and that the outline of the group, though like that of the Pacific atolls, is not due to the growth of corals and formation of coral reefs.

The group consists of about 25 larger islands and a large number of smaller islets, but most of the land is included in the main island (Bermuda), which is about $14\frac{1}{2}$ miles in length, following its curvature, but is seldom two miles wide. This and the other islands at each end of it form a sort of crescent

* Mostly an abstract from a course of six lectures on the Geology and Natural History of the Bermudas (illustrated by over 200 lantern slides), delivered at the Lowell Institute in Boston, Nov. and Dec., 1899.

EXPLANATION OF THE MAP OF THE BERMUDA ISLANDS.

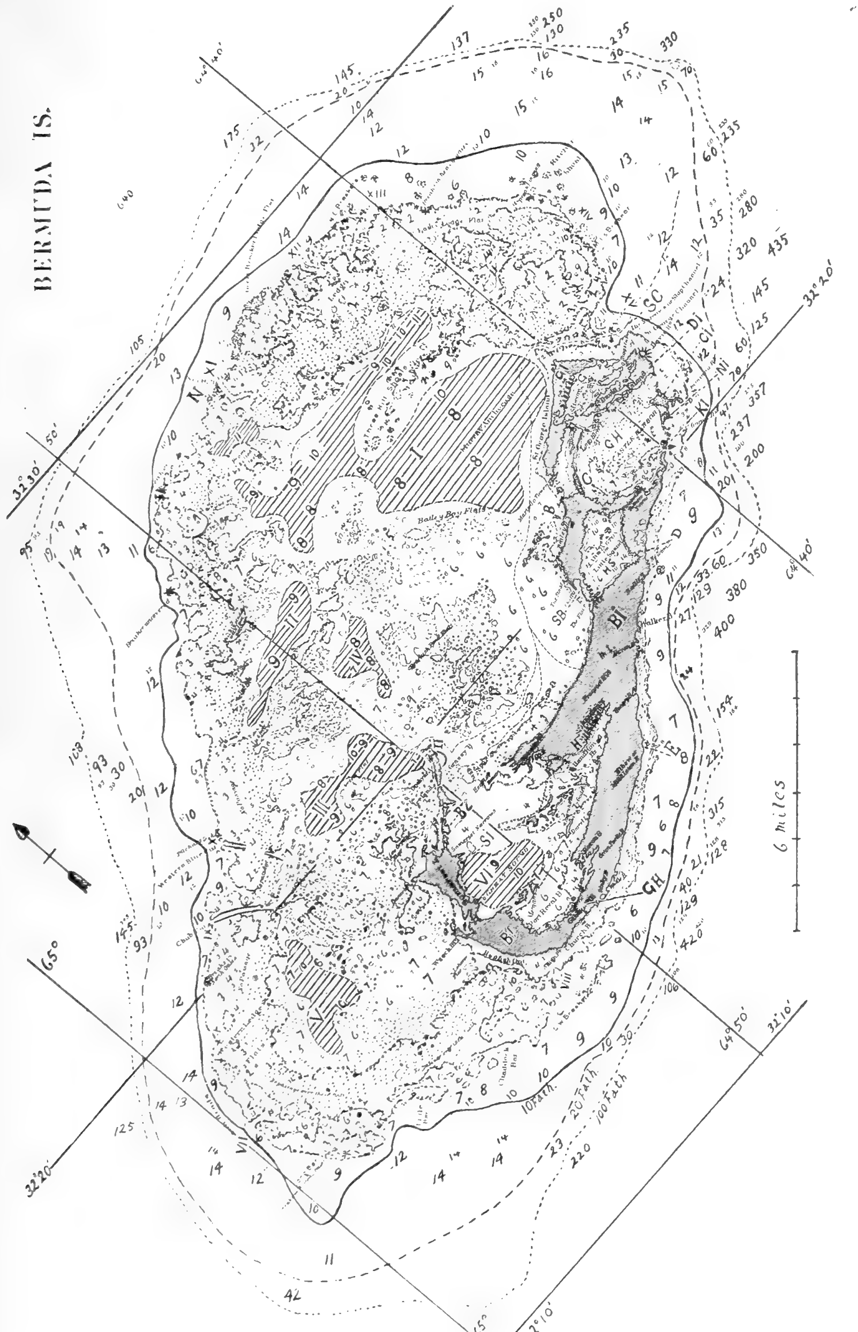
The depths outside the reefs and in the lagoons are in fathoms; those on the reefs and shallows are in feet.

I. I.—Ireland Island and Dry Dock.
BZ.—Boaz Island.
S. I.—Somerset Island.
B. I.—Bermuda or Main Island.
B.—Bailey Bay.
H.—Hamilton, the capitol.
H. S.—Harrington Sound.
S. B.—Shelly Bay.
F.—Flat's Village and the outlet of Harrington Sound.
E.—Elbow Bay, with modern sand dunes.
G. H.—Gibbs Hill Light.
D.—Devil's Hole.
C.—Causeway, destroyed Sept. 12, 1899, by a storm.
C. H.—Castle Harbor.
G. I.—St. George's Island and town.
G.—St. George's Harbor.
S. C.—Main Ship Channel or entrance to Murray Anchorage.
D. I.—David's Island and Light.
C. I.—Cooper's Island.
N. I.—Nonesuch Island.
K. I.—Castle Island and ruins of King's Castle.

The principal submerged sinks or drowned lagoons over 50 feet deep are shaded with parallel lines, and numbered I–VI. Their probable ancient outlets, called "cuts," are numbered VII to XV.

I.—Murray Anchorage.
II.—Blue Cut Sink.
III.—Sink north of Ireland Island, or Western Chub Cut sink.
IV.—Brackish Pond Sink.
V.—Chub Cut or Western Ledge Sink.
VI.—Great Sound Sink.
VII.—Cut in Long Bar, leading to a large passage 3 miles long and 6 to 7 fathoms deep, running S.E. and N.W. inside Long Bar Reef.
VIII.—Hog Fish Cut, 7–10 fathoms deep, leading to Chub Cut Sink, from the southwest.
IX.—Chub Cut, 7–8 fathoms deep, leading to Chub Cut Sink, from the north.
X.—Western Blue Cut, apparently partly roofed over by the reef, leading to Sink III.
XI.—North Rocks Cut, leading toward a small sink 11 fathoms deep, not numbered (North Rocks Sink).
XII and XIII.—Ledge Flat Cuts, 7–9 fathoms deep, connected together inside the outer reefs.

Continued on page 316.


BERMUDA IS.
6 miles

XIV.—Mills Breaker Cut, 10 fathoms deep, leading towards an irregular sink (not shaded) 9 to 14 fathoms deep, and about 2 miles long.

XV.—Main Ship Channel or the Narrows, a narrow cut leading to Murray Anchorage.

NOTE.—The map is much altered from that of Agassiz by the addition of the three contour lines, at 10, 20, and 100 fathoms depths; by shading the deeper parts of the larger lagoons, where the depth exceeds 50 feet; and in some other respects. It is based on the Admiralty Chart, reduced by photography.

FIGURE 2.—Cliff of æolian limestone on the South shore, showing the irregular stratification and the deeply pitted rough surface coated and infiltrated with calcite, characteristic of most of the cliffs that are exposed alternately to the action of the sea spray and dry air.

about 15 miles in length, in a straight line, but this crescent is continued around, in the form of an ellipse, by the innumerable submerged or nearly submerged flat reefs, many of which are bare at low tides. The whole ellipse probably covers over 220 square miles, but the dry land contains scarely 20 square miles.

The outer line of reefs, on the northern side, encloses a great bay of shallow water, very much obstructed by innumerable flat reefs, large and small, many of which are nearly or quite bare at very low tides. But several considerable areas exist in this bay, where the depth is from 6 to 12 fathoms (rarely 14) and the bottom is composed of fine calcareous mud and shell-

FIGURE 3.—Pinnacle rock of æolian limestone on South shore, showing sand-drift stratification, above, and the deeply pitted, rough, hard surface below, infiltrated and coated with calcite.

sand. (See map, areas I–VI.) Castle Harbor and Harrington Sound also contain areas of similar depth and character of bottom, the latter being the deeper.

The interior of the larger islands is hilly and irregular, some of the hills being 200 to 268 feet high. Nearly the whole of the southern side of the larger islands is composed of high precipitous cliffs, with a few small coves. Similar but less elevated cliffs form much of the north shore, but are not so continuous. The rocks are almost everywhere rather soft

æolian limestones, with strata dipping irregularly in all directions and often at high angles, so that they wear away on the coast into very rough and rugged forms. Where these rocks, along the shore and between tides, are exposed alternately to the sun and to the action of salt spray, they become deeply pitted and honeycombed, and often very jagged, while the surface and a layer beneath become very hard and solid by the infiltration and deposition of calcium carbonate. In this condition these rocks often give a ringing sound, when struck with a hammer, and are resistant to erosion. (Figs. 2, 3.)

My attention was directed more particularly towards the determination of the precise nature and mode of formation of the white calcareous mud and sand on the bottom of the bays and lagoons, and of the beaches, and its probable rate of formation; to the probable rate and mode of erosion of the cliffs and reefs; to the rate of subaërial erosion and formation of the "red clay" soil; to the evidence of former elevation and subsidence of the land and its extent; and to the possibility of connecting such changes with corresponding changes on the American coast in the Glacial and Post-glacial periods.

My general conclusions may be summarized as follows:

1. The present Bermuda Islands are a small remnant of a very much larger island which formerly occupied the same position, and which we may call the Greater Bermuda. This Greater Bermuda covered an area of about 300 to 400 square miles; was elliptical in outline, about 28 miles long and 15 wide, and the highest land must have been at least 375 feet above the sea. It had large areas of sand beaches and flats, bare at low tide. The existing islands contain only about 20 square miles (12,378 acres), and the highest hill is 268 feet. (See map, fig. 1.)

2. A subsidence of at least 80 to 100 feet took place at a period comparatively recent (geologically speaking), by which the Greater Bermuda was depressed below the level of the sea, for the most part, converting what were lowlands into sounds and bays, and changing the shore cliffs of the Greater Bermuda into a series of islands and reefs, corresponding to the present outlying reefs, most of which now, after a long period of erosion, hardly rise above the sea-level. The submerged reefs, as shown by the excavations for the dry dock, are composed of the sand-drifted rock to the depth of at least 50 feet below the present sea-level. This observation shows that the amount of sinking has been at least 50 feet. Other facts, referred to below, show that it must have been at least 80 to 100 feet.*

3. The Greater Bermuda, as well as the present Bermudas, and also the submerged reefs and islands, so far as visible or

* For a discussion of this (see pp. 324–327).

excavated, are composed of shell-sand drifted from the beaches and sandy flats by the winds in former times into hills and afterwards consolidated by infiltration and exposure to the atmospheric influences into what is known as æolian limestone. A few local deposits of beach-rock, containing broken shells and corals, are the only certain exceptions to this.*

4. The reefs do not consist of coral, but of æolian rock, made up of shell-sand with very little coral.† The living corals, though abundant, constitute a mere coating over the surface of the reefs, and an imperfect coating at that. Nor do they contribute very much material to the sands or mud. The islands and reefs, though in the form of an atoll, do not form a true atoll, but a *pseudatoll*. Although having the form of an atoll they are not coral reefs,—they are sunken wind-drifted sand-dunes. But they may, perhaps, rest on a foundation of coral rock, of earlier age, now deeply submerged. The living corals help to protect the reefs from rapid erosion.

5. The white sand and mud of the bottom of the bays and sounds and of the beaches consist mainly of small molluscan shells, mostly broken, with a few foraminifera and corallines, and a variable amount of detritus from the erosion of the cliffs. This is a matter that I consider of importance in the geology of the islands, because most of the writers have more or less misunderstood the nature of the material of these sands and their origin.‡ The limestones consist of the same materials. (See figs. 8, 9.)

6. This shell-sand is constantly increasing in amount chiefly by the annual growth and death of small shells, as in former periods, so that the total mass of the islands is probably still increasing, beneath the sea.

7. The periods of most rapid and extensive formation of the beach shell-sand and of the great sand-dunes that formed the hills of æolian limestones were the periods of progressive eleva-

* These deposits of beach rock are in some cases of very recent origin; others are of much earlier date; but all contain only existing species of marine shells. They are seldom more than 10 to 12 feet above high tide. The materials for such coarse beds may have been washed to that height, or even higher, in exposed places, by storms like that of last September. The "base rock" so called appears to me to be only a part of the æolian limestone altered locally by infiltrations of calcite. (See p. 321.)

† One reason for this is because most of the common reef corals at Bermuda are large massive species of *Diploria*, *Mæandrina*, *Orbicella*, *Siderastræa*, and *Porites astræoides*, all of which attach themselves so firmly to the reefs that they are seldom broken off even by violent storms. *Millepora* is the most common branched and brittle form, and is the most common as fragments in the sands and limestones. The star coral (*Obicella annularis*) is common in large masses on the outer reefs. The larger *O. cavernosa* is less common in the same places. *Diploria* forms hemispheres sometimes 5 or 6 feet across, and is abundant. No madrepores occur here.

‡ See discussion of this on pages 328–330.

tion and subsidence in which the elevation was intermediate between that of the Greater Bermuda and the present, or when the land stood from 30 to 60 feet higher than now, thus connecting the extensive bays and sounds into great sand-flats, more or less extensively covered by the tides at high water, and bordered by broad sand beaches laid bare at low water from which vast quantities of sand could be taken and carried inland by the winds. At present the sand-beaches are all of small extent. It is probable that the higher hills of the present land represent the older sand-dunes formed during the elevation of Greater Bermuda.*

8. Erosion has occurred on a grand scale since the submergence took place, cutting away the shore cliffs to a very great extent, converting many of the outer islands into mere platforms of rock, either a little below the level of the sea at low tide or just rising above it, and also occasionally leaving detached pinnacles of harder rock on the outer ledges and reefs, of which the most remarkable are the North Rocks (fig. 11) which stand on a large flat submerged reef about 8 miles from the islands. They are clearly composed of æolian limestone, rendered hard by infiltrations of calcite.

9. The rate of the erosion by the sea has been greatly exaggerated by most writers. Data obtained by me indicate that it must have taken at least 25,000 to 30,000 years to accomplish the erosion of the high cliffs facing on Hamilton Sound, which is nearly land-locked. The data hitherto obtained applies better to the erosion of the cliffs of Hamilton Sound than to that of the outer cliffs. So far, we have not been able to get any reliable data for estimating the amount and rapidity of the erosion of the exposed cliffs, especially of those on the south shore where the erosion is most rapid and extensive. A careful comparison that I have made between recent maps and a good map published 274 years ago shows very little change in the size or outlines of the islands, bays, and harbors since that time.†

* A fuller discussion and more illustrations of this and other points of Bermudian Geology will be given in a more extensive paper, to be published in the Transactions of the Connecticut Acad. of Sciences, Vol. XI.

† The map particularly referred to was made by Richard Norwood, before 1622. "A mapp of the Sommer Islands, once called the Bermudas," London, 1626. Reprinted from an original engraving in the British Museum, by Governor Lefroy in "Memorials of the Discovery and early Settlement of the Bermudas or Somer's Islands," London, 1877 (end of vol. I). A much less complete edition of this or an earlier map was published in 1624, in Capt. John Smith's "General History of Virginia, New England, and the Summer Ils."

A later survey and map by Norwood, completed in 1663, has also been reprinted by Gov. Lefroy, in the work cited, p. 644, but the shore lines are much coarser and less accurate in the latter, which was made mainly with reference to the transfers of land and the boundaries of estates. See additional discussion of the maps, p. 324.

10. A process of secondary infiltration of the rocks with solutions of calcium bicarbonate and the deposition of calcite, thus filling the pores more or less completely and hardening the rock much beyond its original condition, is a very important factor in Bermudian geology as affecting both the littoral and subærial erosion. There is good evidence that this has taken place extensively, not only at the surface but at a considerable and variable depth below the surface of the rocks, at levels corresponding to the variable upper limits of the zone of aqueous saturation, where the evaporation of the water and periodical sinking of the water level would cause such a deposit to form. As all the porous rocks, up to the level of mid-tide, are saturated with sea water, on which the layer of fresh water rests,* this zone of calcification would always be higher than that level and locally might be many feet above high-tide level.

11. Probably most of the so-called *base-rock* has been formed in this way, by the calcification of ordinary æolian limestones.† Thus a "base-rock" of this kind would naturally be most often formed a little above high-tide level, *underlying unconformably* the æolian limestones. This is the position in which this rock generally occurs, but it is also found at various other levels, as might be expected, and it is often lacking, both in natural shore-sections and in artificial ones.‡ Similar calcification of the rock may occur locally at or near the surface.

Doubtless similar effects producing similar results have occurred at various levels and at various periods during the former changes in the elevation of the islands, for both elevation and submergence were probably intermittent, with long periods of rest.

Rocks exposed to the surf along the shores, both between tides and high up on the cliffs, become deeply pitted and honey-

* Shallow wells and tanks have often been excavated on the islands, but when they go below mid-tide-level the water at the bottom is always salt or brackish, and the fresh water, which floats on the salt, can only be obtained fit for use at certain stages of the tide.

† The "base rock" sometimes shows distinct *æolian stratification*, though it is more commonly nearly homogeneous and without stratification where best developed. It is composed of shell-sand like the ordinary æolian rocks. I could not find evidence that the so-called *base rock* represents a distinct period as explained in sections 4 and 5. Mr. A. Agassiz also failed to recognize them as a distinct formation, but Professors Rice, Tarr, and Stevenson all considered them a distinct deposit of earlier date than the ordinary æolian limestones, because they appear in some cases to underlie the latter. But if the above view of their origin be correct, this does not indicate a distinct formation nor earlier period.

‡ The rock found beneath the peat bog at Ireland Island at the depth of 50 feet has been described as "the ordinary base rock" with irregular upper surface, and also as an *æolian limestone*. In either case it was doubtless consolidated above sea level by infiltration. The more recent loose deposits (about 30 feet thick) above the peat were *not consolidated* and consisted of shell-sand, broken shells and massive corals and pebbles. Such materials at Bermuda do not seem able to consolidate into limestone *beneath the sea*.

combed and very jagged and rough, and at the same time very hard owing to infiltration of the surface and deposition of calcite in consequence of the evaporation of the water of solution. (See figs. 2, 3.)

12. Infiltration and solidification of the rocks have also occurred on the surfaces of vertical cracks and along subterranean water passages, causing various local hardenings of the rock which become very evident during denudation.

The formation of detached columns and pinnacles of rock by erosion, and especially of such places as Cathedral Rocks (fig. 5), is largely due in most cases to the previous local hardening of the rock along fissures that have served for the passage of calciferous waters, causing the hardened portions to longer resist erosion.

13. Subterranean erosion has taken place on a large scale, giving origin to extensive caverns and water channels. (Figs. 5, 6.) The roofs of these have often fallen in, producing sinks, ponds, and marshes, large and small. Probably the basins occupied by Harrington Sound, Castle Harbor, and others similar in character were in large part excavated by subterranean waters when the land stood at its highest level.* But this action probably does not occur much, if at all, below sea level. Therefore if the deep passages among the reefs, and the deeper parts of the sounds (see map 1, areas I–VI), were made in this way, it would have required a former elevation of over a hundred feet above the present level. (See p. 326.)

14. The "red soil" of Bermuda and other native soils are mainly the residue left after the destruction and solution of the limestones. Its formation has been a very long and slow process, for the amount of impurities in the limestone is very small—probably less than an average of 1 per cent. Some of this material in the limestone was probably of foreign volcanic origin (floating pumice and ash from the West Indian volcanoes perhaps), but some of it may have been derived indirectly from the ancient Bermudian volcano or from the craters represented by the Challenger and Argus Banks, which may have remained active much later than the main crater.†

* It is possible, however, that the central basins within the reefs were due in part to the original form of the volcanic summit, and correspond to several more or less separated and filled up craters of the ancient volcano, while the outer reefs may correspond to a certain extent with their more or less elevated margins, which may have been first occupied by ancient coral reefs now deeply submerged. Deep borings can alone determine this question.

† This refers to the possibility that some of the materials of the older æolian limestones may have been derived by rewashing from preëxistent rocks, now submerged, which may have contained beds of volcanic ashes or pumice of local origin. No beds containing any notable amount of volcanic ashes are known to exist at present on the islands, but most of the limestones leave, after solution, a small per cent of grains of probable volcanic origin.

15. Probably the greatest elevation of the Greater Bermuda was coincident in time with the Glacial Period of North America and Europe. The same elevation of the northern regions of America and Europe which produced the Glacial Period, or was coincident therewith, also affected Bermuda, which lies only about 700 miles south of Nova Scotia, where the elevation was far greater in extent. (See p. 337.)

16. The period of greatest subsidence was probably coincident in time with the Post-Glacial or Laurentian period of submergence on our coast. The subsequent small elevation, after the greatest subsidence, is supposed to have been only six to ten feet, while the coasts of Nova Scotia and northern New England have been elevated more than 100 feet since the greatest depression. This movement, also, was probably due to the same causes in both places.

17. The climate of the Greater Bermuda was warmer, more windy, and more moist than at present, so that certain West Indian species have become extinct in Bermuda, but are found as fossils in the old limestone, mingled with other species still common on the islands. The storms were probably more severe, owing to the proximity of the glaciated American coast, and consequent sharper contrasts in temperature. (See p. 338.)

18. The visible Bermudas, and also the Greater Bermuda, rest on the hidden summit of an ancient volcano. This ancient volcano is conical in form and rises over 15,000 feet above the bottom of the surrounding deep-sea. The slope of this submerged volcano is exceedingly steep, thus indicating its volcanic nature, which is confirmed by very unusual local magnetic variations about the islands.* These variations indicate the presence of large masses of iron-bearing volcanic rock at no great depth below the surface.

This volcanic cone probably had a considerable elevation above the sea, but was cut down to or below sea level by the waves to form the foundations of the Greater Bermuda.

19. Two other similar, but smaller, peaks lie a few miles to the southwest of Bermuda, and form what are known as Argus Bank and Challenger Bank,† both having, in general, from 20 to 40 fathoms of water over their surfaces, but Argus Bank

* See Voyage of the Challenger, Narrative, I, p. 140: "The observations made by the Expedition showed that the variation differed in various parts of the island as much as 6°, ranging from 4° W. to 10° W., the smallest amount being found at a small islet just under the lighthouse on Gibb's Hill, and the greatest at the point on the west side of Clarence Cove." Such variations do not exist at sea, a few miles from the islands.

† The nearest is the Challenger Bank. It lies 13 miles S. 50° 14′ W. from Gibb's Hill light It is about 10 miles in circumference. The distance from the 100 fathom line of Bermuda to its inner edge is not over four miles.

rises in one place to within 8 fathoms of the surface of the sea. These two peaks and Bermuda are connected together by a ridge, covered with water only 580 to 690 fathoms deep, while the surrounding sea, on all sides, is over 2,000 fathoms deep. The submerged slope of the Bermuda Mountain, on the north side, is steeper than that of any known large volcano upon the dry land. It falls off 1250 fathoms in 6 miles. That is at the rate of about 1250 feet to the mile. The slope of the Argus Bank is, on one side, 7620 feet in 10 miles. (See fig. 4.)

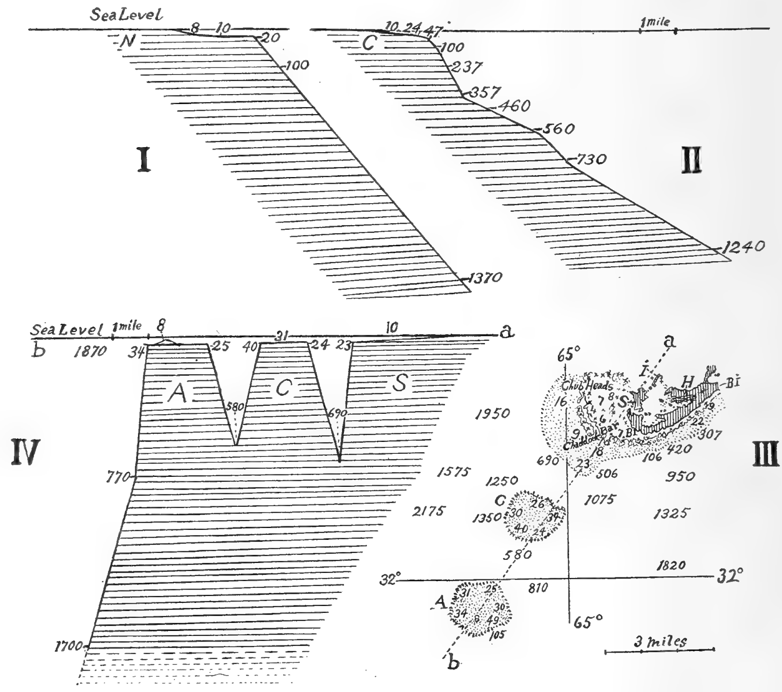


FIGURE 4.—I. Sectional diagram of submerged slope northward from North Rocks (N);

II. The same southward from Castle Harbor (C).

III. Sketch map showing the situation of Argus Bank (A); Challenger Bank (C); and southwestern end of the Bermudas; Somerset Island (S); Ireland Island (I); Main Island or Bermuda (B. I.); Hamilton town (H); *a*, *b*, line of the section shown in IV.

IV. Section through Somerset Island (S), Challenger Bank (C), and Argus Bank (A), along the line *a*, *b*, in III.

All soundings are given in fathoms.

Evidences of Subsidence. Figs. 1, 5, 6.

In making the excavation for the great dry dock at Ireland Island a bed of peat was found, containing cedar stumps in a

vertical position at 45 feet beneath the sea, and below this æolian limestone or "base rock." In the peat bed were found shells of the snail (*Pœcilozonites Bermudensis*), still living, and the bones of birds (undetermined).

Among other facts indicating subsidence are the various caverns with large stalactites and stalagmites now depressed more or less below the level of the sea and filled with sea water, which is said to be at least 40 feet deep in some of them. The stalactites descend into the sea water in some cases. The Walsingham caves are of this description and there are others quite as remarkable. Devil's Hole, in which great

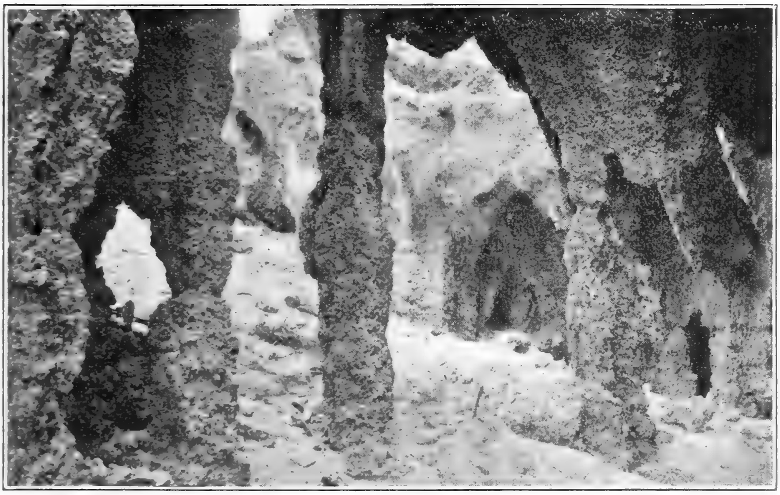


FIGURE 5.—Cathedral Rocks on Somerset Island. This appears to be the ruins of an ancient cavern and water passages which have been partly broken down and dissected by the sea. The roof has partly fallen down. The columns are hardened by infiltration and roughly pitted.

numbers of fishes are kept confined, is such a cavern from which the roof has fallen away. The sea water in it is said to be 40 feet deep.

Some of the existing peat bogs are said to extend to the depth of 45 feet beneath sea level, and to contain very large cedar stumps. Such deposits cannot be formed here except above sea level, for, owing to the porosity of the rocks, all depressions below the sea level become filled with sea water. Thus these peat bogs afford evidence of submergence, for the peat consists of the remains of various terrestrial plants.

The evidence of still greater subsidence is derived from the

depth and character of the various more or less enclosed bays, sounds and harbors, and of the channels leading out from them. It is considered highly probable that these depressions represent valleys of erosion that were excavated on dry land at the period of the greatest elevation of the Greater Bermuda. At that time the extent and elevation of the land must have been such as to have given rise to violent torrents of water among the hills during the rainy seasons; such torrents would have acted in the usual way, but many of them may have disappeared in "sinks" in the valleys, before reaching the sea, as many large streams do in the limestone regions of our southern

FIGURE 6.—Chasm and natural bridge on Cooper's Island. This appears to have been an ancient underground water-way, now partly submerged, from which a part of the roof has fallen.

states (West Virginia, etc.). In that case they would have eroded subterranean channels and caverns which eventually would have collapsed producing larger and deeper sinks, until finally their deepest channels would have cut down nearly to sea level, and the depressions or valleys of erosion would in some cases have become nearly as deep. At present the landlocked Harrington Sound, in its deepest parts, is 80 to 95 feet deep. There are many places in Great Sound, Murray Anchorage, and other parts of the bay within the reefs, where the

depth is from 50 to 80 feet or more.* Some of the narrow passages in the outer reefs have similar depths. They are now apparently filling up by the accumulation of the shell-sands on the bottom. This must certainly be the case in Harrington Sound and Great Sound, where there are not sufficient tidal currents or storm waves to carry away even fine mud. In fact, everywhere over the bottoms of the enclosed sounds the accumulations of recent soft calcareous shell-sand and mud is far in excess of the amount carried away mechanically and by solution combined. Possibly the currents may be sufficient, in the main ship channel, to carry away the detritus and prevent filling up rapidly, but they are not sufficient to effect erosion of the bottom.

Therefore it is reasonable to conclude that all such depressions give evidence of former erosion above the sea and consequently of later submergence to the extent of their greatest depth or more.

These sunken areas, within the outer reef, are identical in character and depth with Harrington Sound, which they often exceed in size. The latter has also a deep subterranean outlet into Castle Harbor, besides its shallow outlet at Flat's Village. Were the high ridges around Harrington Sound eroded to the level of the reefs, it would agree in every way with such areas as II, III, or V, except that it is rather deeper.

The bottom outside the outer reefs is covered with rough ledges or broken masses of limestone to the depth of 150 feet or more, and the slope is gradual to 300 feet or more. This zone represents, most likely, the shore ledges, beaches, and shallow waters of Greater Bermuda. If so this zone of rough bottom would indicate a submergence of at least 150 feet, which is by no means improbable.

The present very uneven surfaces of Argus and Challenger Banks are like those of Bermuda, and indicate erosion when they stood above sea-level. Some considerable parts of their summits are now 180 to 240 feet beneath the sea; other parts (Argus Bank) are only 8 feet. Erosion by waves on such sunken banks would be a levelling process and does not extend, even in great storms, with noticeable effect, more than 120 feet below the sea-level.† Hence it is probable that they have subsided at least 240 feet since they were eroded.

* The most important of these are represented on the map (Fig. 1) by the areas shaded with coarser parallel lines (I–VI). The deep narrow passages leading out from these and sometimes (as at X) running under the reefs, are numbered VII–XV.

† George's Bank and Nantucket Shoals, off Cape Cod, maintain themselves in the face of the most violent storms. Although composed only of loose sand and gravel, their shallowest parts rise to within 25 to 30 feet of the sea-level. This indicates that the abrading action of the waves decreases very rapidly even at such depths.

Reëlevation of the Bermudas. Fig. 7.

The evidence in regard to the reëlevation of the islands after their greatest depression is not entirely conclusive. Professor Rice adopted the view that such an elevation, of small amount, has taken place, but Mr. Agassiz took the opposite view. At most, the elevation was not over 12 to 15 feet.

The evidence depends partly upon the existence of local beach deposits, containing existing marine shells, at various localities, as at Ireland Island, described in detail by Professor Rice. The most elevated beds of this kind are not over 15 feet above the sea. Mr. Agassiz suggests that such deposits could have been thrown by storm waves to such heights, and therefore that they do not prove elevation. This is no doubt true in exposed situations, but some of these beds are situated in partially sheltered harbors where such violent wave-action would probably not occur. It appears to me probable that part of these beds were made just below sea-level, or between tides, and therefore do actually give evidence of elevation. That they are not more extensive and general may be due partly to the abruptness of the shores in most places, and partly to subsequent erosion. Still we should expect to find many such deposits around the low shores of the land-locked bays and lagoons, where they are not known to exist, had such a general elevation taken place, even to the extent of 5 or 6 feet.

Another reason for thinking that an elevation of several feet has occurred is the peculiar character of the erosion on many of the cliffs, for a second very marked plane of maximum erosion can often be observed 6 to 10 feet above the one situated at or a little above the present high-tide level. In many cases the cliffs are thus undercut at two levels. In other cases cavernous places or "ovens" of large size have been excavated entirely above the reach of ordinary waves. This is the case on the islands in land-locked Harrington Sound as well as in more exposed situations. It seems hardly probable that occasional severe storms could effect this kind of erosion at such elevations. (Fig. 7.) This upper zone of erosion has apparently been mostly removed by subsequent erosion on the more exposed cliffs, especially on the south side.

Nature and Origin of the White Sands. Figs. 8, 9.

Most writers have spoken of the white sand of the beaches and lagoons as "coral sand." Mr. A. Agassiz considered it as chiefly derived from the erosion of the limestone rocks of the shores. If this were the case, it would imply a rapid decrease in the total mass of the islands, for much of the finer sand and mud in shallow water is stirred up by storms, and then is con-

stantly carried away by waves and currents into deep water. Mosley was, I think, the first writer who stated that the sand is chiefly composed of shells* and that the same is true of the limestones.

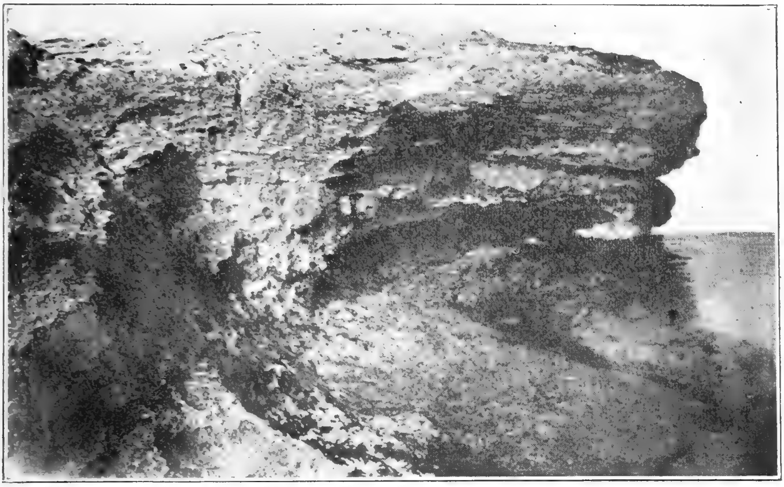


FIGURE 7.—Cliffs of æolian limestone on the North shore, showing two strongly marked planes of erosion, the upper one several feet above high-tide level. The honeycombed rocks are hardened by infiltrations and coatings of calcite.

Our party dredged up large quantities of the sand and mud in various depths in Harrington Sound; Castle Harbor; Murray Anchorage, Bailey Bay; and in the main Ship Channel, down to depths of 50 feet or more. A large amount was brought back for careful study.

All these samples, whether coarse or fine, consist mainly of molluscan shells, mostly of small species, and badly broken up, especially in the finer varieties (fig. 8).

More than 50 species of small shells, in fresh condition, have been picked out from a small part of this material. The most abundant species are small bivalves of many kinds, but small gastropods, such as *Cerithium*, *Turbonilla*, *Cæcum*, and *Rissoidæ* are also abundant, and of many species, as well as various larger forms in the coarser samples (fig. 9). With the shells are a number of species of Foraminifera, but these are not abundant. There are also, in the coarser samples, a very few bits of broken branched corals (chiefly Millepora), and a few fragments of calcareous algæ, sea-urchins, bryozoans, etc.,

* Notes by a Naturalist on the Challenger, p. 19, 1879.

together with a few small fragments of æolian limestone and particles of coal and cinders from steamers.

The shells, on the average, constitute about 80 to 90 per cent of the whole mass; limestone detritus perhaps 5 per cent.

The shells are mostly recently dead. Their generally broken condition (fig. 9) is due to the fact that they have mostly been swallowed and passed through the intestines of the large sea-urchins (*Toxopneustes*), and two species of large holothurians (*Stichopus*), which are very abundant everywhere on these sandy bottoms, and whose large intestines are always found

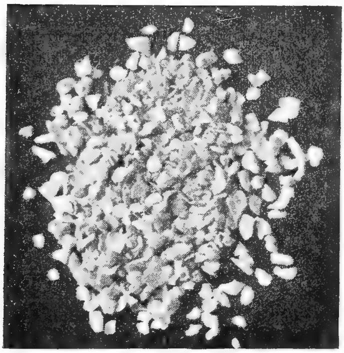


FIGURE 8.—Sample of shell-sand from off Bailey Bay in 4 fathoms. × 1½.
FIGURE 9.—Shell-sand from main Ship Channel, in 6 fathoms. × 1½.

filled with the sand. Many of the abundant smaller fishes also feed largely on the shells, as do some of the crabs. All these creatures, and others, are in fact continually at work killing and breaking up the shells, large and small. Such mollusks are, however, very prolific and mature rapidly, so that they are able to keep up their customary numbers.

Subærial Erosion.

In the Bermudas, owing to the equable climate and absence of frost, the phenomena of erosion and subærial disintegration of the rock is very much simplified, as compared with Europe and the greater part of North America. There is every reason for believing that the present conditions have continued for an immense period of time, without much change in this respect. Therefore observations that would give a fairly accurate measure of the present average rate of disintegration of the limestone would be of great value in determining the time required for the great changes that have taken place in past time. So, likewise, we might, by a careful study of the forma-

tion of the "red soil," as a decomposition product, or insoluble residue left after the solution of the limestone, be able to estimate approximately the total age of the dry land of the Bermudas. At present we can only say that this process of accumulation of the red soil is an extremely slow one. It probably requires the destruction of at least 200 feet of limestone to form one foot of soil. Probably the amount of this native soil on the island, if evenly distributed over the surface, would amount to at least two feet. Though there are large tracts where the average depth of soil is not over six inches, and also tracts of nearly bare rock, there are depressions and valleys between the hills where it is many feet deep. This light soil is easily washed from the hillsides into the valleys by the heavy rains, unless it be closely covered by grass or some other vegetation. On the contrary, as there are no brooks or streams of fresh water, comparatively little of it is carried into the sea and wasted.* Hence it follows that unless these limestones disintegrate with unusual rapidity, it must have taken a very long period to form even one foot of soil. Some data that I obtained by examining the ruins of the old stone forts on Castle Island and others, built before 1620, show an unexpectedly slow rate of disintegration of the ordinary limestone used in the walls and buildings. This was confirmed by observations made at other places. These data would make the average rate of subærial disintegration for the harder æolian limestones to be less than an inch in a century. This would require 240,000 years for the destruction of the 200 feet of limestone necessary to form one foot of soil.

But there are, in many places, areas of much softer limestones which decay far more rapidly and furnish soil much more freely. Such tracts of soft limestones have, by their decay and solution, given origin, in many cases, to the sinks, ponds, marshes, and caverns that abound on the larger islands. But many of the softer limestones when exposed to the air, as in the road cuttings, become, in a few months, very much harder and resistant to decay. It is rare to find in the extensive road-cuts any great portion of the nearly perpendicular side-walls that have fallen away by decay.

My observations, therefore, on this point, though not very satisfactory and far too few in number, point to a great antiquity for the Bermuda limestones,† though recent in a

* This was probably not the case in the time of the Greater Bermuda, for torrents and large subterranean streams probably existed then, owing to the larger expanse of high land.

† Doubtless investigations carefully made as to the rate of excavation of the caverns by solution of the rock, and of the rate of formation of stalactites, would show the same thing, for some of the Bermuda caverns, now partly filled with sea water, are of considerable extent and depth, with large stalactites that extend

geological sense. It would, in fact, appear that the age of the older or greater Bermuda must be as great as the Glacial Period at least.

Littoral Erosion. Figs. 2, 3, 7.

The same result was arrived at from a study of the rate of erosion by the waves, as shown on the masonry of the causeway leading to St. George and in other places. This rate of erosion was found to be unexpectedly slow, under ordinary conditions, owing to the absence of ice and frost, and because there are no deposits of hard sand, gravel, and pebbles on the shores, which the storm waves might pick up and use as tools of destruction, by dashing them against the bases of the cliffs and against each other, as they do on our rocky coasts.* It is only during the severe storms and hurricanes, which occasionally occur, that much erosion is accomplished.

Most observers, seeing the evidence of great erosion on all sides, and considering the softness of the rocks, have naturally supposed that the erosion has taken place far more rapidly than is the case.

The causeway between the main island and St. George's was completed in 1871. It was about a mile long, and well built of native limestone blocks of large size. It was wide enough for two or three carriages abreast. It included an iron drawbridge and several smaller bridges under which were strong tidal currents, flowing in and out of Castle Harbor. It was so situated in the passage between the islands that it was partly sheltered, and ordinarily it would not be exposed to the full violence of storms. By an examination of the masonry of this causeway at several places I found that during the 27 years that it had been built the erosion by the sea rarely amounted to an inch in depth, where most active, and the average erosion was less than half an inch, between tides; most of this, also, had evidently been effected within the first few years after its

far below the surface of the sea water. It is said that the salt water is 40 feet deep in some of the partly submerged caves. The sinks and ponds, that are believed to be due to the falling in of the roofs of large caverns, also give evidence of a very long period of disintegration that must have preceded the great subsidence, for such caverns must have been excavated while above the sea-level.

* On the coast of Maine and at Grand Menan Island, Bay of Fundy, the frost every year throws down from the high basaltic cliffs vast quantities of angular blocks of hard trap rock, large and small. These are tossed about, smashed together, and dashed against the base of the cliffs, rolling up and down the slope of the beach with every storm-wave, with a thunderous noise, audible for many miles, so that in a few months they become round paving stones and small pebbles. The smoothing of their surfaces is aided by the coarse gravel and sand mixed with them.

Nothing of this kind can occur at Bermuda, where the fragments of soft limestone are quickly crushed and broken by the waves until nothing is left but soft calcareous sand and mud, with very little erosive power.

erection, before the stones had acquired their hard superficial coat of infiltrated calcite. It is true that these stones were selected from the harder beds of limestone and therefore had more than the average resisting power, but, as a matter of fact, after any of the soft limestones become infiltrated by calcite the surface is about equally resistant, so that the differences in power of resisting erosion by the sea, between tides, is much less than it would otherwise be.

Allowing the average to be even one inch in 25 years, it would have required at least 25,000 to 30,000 years for the sea to have eroded the high perpendicular cliffs facing on Harrington Sound to the extent that they have been eroded. And yet these cliffs are far more sheltered than the causeway, for Harrington Sound is completely landlocked, with such a long and narrow channel connecting it with the outer bay, that it has scarcely any tide,—less than a foot. It is only two miles wide, so that no great seas can be formed in it, even in severe storms.

I have compared the causeway erosion with that of these sheltered cliffs, because a comparison with the cliffs on the exposed shores, especially with those on the south side, against which the storm waves dash with incredible violence,—would be far less justifiable. In fact, I did not obtain any reliable data as to the rate of erosion of the exposed cliffs of the south shore, except the observation that on Castle Island the ancient sea-walls of the forts were often built with their foundations on a shelf of limestone some distance below the original brow of the seaward cliffs, and they have not yet been undermined, but stand firmly where they were apparently put about 275 years ago. Some stairs cut out of the solid cliff-rock, in early times, going down to the water, are also still serviceable, but I could not learn the exact date of their construction. In fact, these old works, as well as the early representations of them, indicate that this very exposed small island has not been eroded to any noticeable extent during 275 years.

Hurricanes.

During a violent hurricane last autumn (Sept. 12) the entire causeway, described above, was utterly demolished, scarcely one stone having been left on another. The vast seas that did this destruction came in from the southeast through the narrow passage between Castle Island and the other islands that protect Castle Harbor on the south side, and then, after driving through the shallow water and between the numerous reefs of Castle Harbor, they still had sufficient power to overthrow this substantial wall of masonry. The same storm destroyed nearly all of the stone docks and retaining walls in St. George's

harbor, and damaged many buildings there. At Ireland Island it nearly destroyed the extensive breakwater that protected the dry dock. It did immense damage in other ways, all over the islands. Many of the cedars and other trees were blown down and others were badly broken.

A single storm like this probably effects more in the way of eroding the high cliffs than a hundred years of ordinary weather would. It would not surprise me to learn that parts of the old fortifications on Castle Island had been undermined and swept away by that storm, nor that some of the North Rocks had been overthrown. The local (Bermuda) papers referred to the seas in this storm as washing over the cliffs on the south side, where they are over 50 feet high, and carrying with them large blocks of stone and other detritus to points far above high-water mark. Such a storm, therefore, by washing up over the dry land large quantities of broken shells, corals, stones, etc., may easily produce deposits of "beach rock" overlying beds of æolian limestone, far above the sea-level, and thus produce a deceptive appearance of elevation of the land.*

Early Maps and Sketches.

Another way in which we can get some idea of the rate of erosion of a coast, and of changes in level, is by comparing early maps, when reliable ones exist, with recent ones. Fortunately the Bermudas were carefully surveyed soon after they were settled (1612) by a competent surveyor, Richard Norwood, who resided there many years. His survey was mostly made between 1615 and 1622. His completed map, dated 1622, and engraved in Amsterdam, was published and for sale in London in 1626; and this seems to be the best edition of it, for the outlines are engraved clearly and with care. (See p. 315.) Two other editions were published about the same time. A later careful survey was made about 1730 by Lempriere, whose first edition I have not seen. It was republished in "The West Indian Atlas," by Thos. Jeffreys, London, 1780.

I have carefully compared these early maps with the most recent Admiralty charts and with other maps made during the past century. The changes in outlines are very slight. In some cases small bays or coves have been converted into lagoons by the formation of sandbars across the mouth. In other cases such bars have apparently been washed away, converting a small lagoon into an open cove. These are phenomena that are common on all sandy shores, and may take place during a single severe storm.

* A similar severe hurricane occurred here just 60 years earlier (Sept. 11, 1839). Other remarkable hurricanes are recorded as having occurred in 1619 (two in November); 16th Aug., 1629; 1668, (no date); Oct., 1780.

But there is evidence from these early maps that no changes in level of appreciable amount have taken place during 275 years, nor any notable decrease in the size, even of the smaller islands, by erosion. Had any change of level taken place, it would have produced marked changes in the size and form of the shallow lagoons and bays with low shores, such as Mullet Bay. But the ancient maps correspond remarkably well with the modern ones in respect to the size and form of all such bodies of water.

FIGURE 10.—Facsimile of the reverse of the ancient seal of the Bermuda Company, engraved on the border of Norwood's map of Bermuda, published in 1626. It shows the wreck of May's vessel in 1593, alongside of North Rocks, which then appeared much as at present. Enlarged $1\frac{1}{2}$ times.

On the Norwood map of 1626, in the two lower corners, are engravings of the seal of the original Bermuda Company. On the reverse side of the seal (fig. 10) there is a view of a wrecked vessel alongside of two high rocks, which are easily recognized as the two main North Rocks. The vessel, with broken masts, stands upright between the largest rock and a small one that exists to the right and is therefore concealed by the hull of the vessel. In a photographic view (fig. 11) taken several years ago by Mr. Hyle, of Bermuda, a man stands where the vessel stood and the two views are apparently from nearly the same

point. The two rocks in the sketch are represented as nearly equal in height, but now one is decidedly lower than the other.

This ancient sketch, imperfect as it naturally is, corresponds remarkably well with the outlines of the rocks, as seen in the photograph. This proves that these rocks have undergone but little change in general form since the early settlement of Bermuda, for this seal was probably engraved as early as 1615–18.

FIGURE 11.—North Rocks. From a photograph taken by Mr. J. R. Hyle, previous to 1884.

The sketch was very likely made by Mr. Norwood for this purpose, for he was a man of good ability as a draughtsman, and was making his first survey in 1617. The scene probably commemorates the wreck of a French vessel on the 17th of Nov., 1593, on board of which was one English seaman, Henry May, who published after his escape to England, in 1594, an account of his experiences and a fairly good but brief description of these islands, which, up to that time, were known in England only as dangers to be carefully avoided. Part of the crew of this vessel were saved (about 26 persons), and they subsequently brought ashore their provisions, tools, and the fittings of the vessel "before she split." They remained on the islands five

* That this sketch does not represent the wreck of the "Sea Venture," with Sir George Somers, Sir Thos. Gates and their party, July 28, 1609, is evident, for according to the narratives of Somers and others of his companions, their vessel went aground on the southeast side of the islands, within about a quarter of a mile of the shore, and they landed at a bay then named Gates Bay from Sir Thos. Gates. No other important wrecks occurred about that period, so far as known.

months, while they built a small vessel (18 tons) of native cedar wood, with which they sailed to the Banks of Newfoundland and joined the fishing fleet and were thus taken back to Europe.

May, in his narrative, states that when they went ashore, in the night, they supposed they were on the shore of the island, because of the "hie cliffs," but in the morning they found that they were seven leagues away from it. He also says that after building a raft they towed this ashore "astern of their boat," and that "we rowed all the day until an hour or two before night yer we could come on land."

Historians and others have been misled by this statement and have even imagined that they must have been wrecked on some far more distant island which has since been worn away or submerged.* But it is evident that May meant that it was seven leagues *as they had to row*, for they could not cross the reefs at that point, in the surf, and must have rowed along outside of the reef till they reached the present ship channel and there entered the bay and landed, probably on St. George's Island. This would have caused them to row about seven leagues and would doubtless have taken all day with the boat heavily laden and towing a raft astern. He mentions that there were wild hogs there at that time, showing that they must have been introduced there at an earlier date, perhaps accidentally from some wreck, but more probably intentionally by some of the buccaneers, as was customary in those days.

A comparison of several photographs taken at various times within the past thirty years, shows but little alteration in these North Rocks, but some very severe storm may suddenly overthrow them. They are situated near the extreme edge of the outer reefs, about eight miles from the islands. They stand on an extensive patch of flat reef, part of which is laid bare by low tides. They are 15 or 16 feet high and are evidently the remains of an island of considerable height and extent that has been nearly worn away to the sea-level by erosion. But the evidence from the ancient seal indicates that the erosion even in this exposed situation has not been rapid, though these rocks seem to have decreased somewhat in height.

Correlation with geological changes on our coast.

Professor Rice thought it possible to compare the changes of level at Bermuda with those of the American coast. Mr. Agassiz considered it useless to try to do so, mainly, it appears, because of the volcanic nature of the substructure. How-

* See Lefroy, Memorials, vol. I, p. 9. Also, Jones, Recent Observations in the Bermudas.

ever, there is no evidence of any volcanic activity in this region during several geological periods and therefore this consideration may have no importance.* In regard to the probable correlation, I differ materially from Professor Rice, for I consider that the period of greatest elevation was coincident with the great continental elevation of the Glacial Period, that affected the northern parts of America and Europe and doubtless, also, the intervening bed of the North Atlantic. As Bermuda is only about 700 miles south of Nova Scotia, where the elevation was very great, it is natural that the same movement, in less degree, should have affected Bermuda. The same correspondence in the periods of Post-glacial subsidence and reëlevation would be expected to have occurred. So far as I could obtain data to indicate the duration of present and past conditions of erosion, they confirm this view. No doubt it would be possible for a resident geologist to obtain much more complete evidence as to the rate of erosion of the Bermuda cliffs than I could obtain by a very brief study of the subject, but my results may be of some value in the absence of something better.

Changes in Climate.

That the climate of Bermuda was warmer during the Glacial Period than at present is inferred because the great elevation of the northern parts of Europe and America, together with the whole bottom of the intervening North Atlantic, that occurred at that time and the southward extension of the shore ice of boreal regions, would have diminished the flow of the Gulf Stream into the Arctic regions and confined it more to the central parts of the North Atlantic. This is confirmed, also, by the existence of large West Indian shells, as fossils, in deposits that are probably of glacial age, on the coast of North Carolina, far north of their present range, and north of the latitude of Bermuda. So, also, a large living West Indian shell (*Livona pica*) is a common fossil in the Bermuda limestone, although it no longer lives north of the Bahamas, so far as known. Its shells were doubtless carried inland by the large land hermit-crabs (*Cenobita diogenes*).† These crabs still continue to occupy the same shells, for the fossil shells weather out of the soft limestones all over the islands and are quickly selected by the crabs for protection. (Fig. 12.) In the older limestone a large fossil land shell (*Pœcilozonites Nelsoni*), peculiar to the islands and now extinct, is often abundant,

* Earthquakes are rare in Bermuda. I have found but two mentioned: one June 25, 1664; one Feb. 19, 1801, neither of which did much damage.

† In the Yale Museum there is a fossil crab of this species found in the Bermuda limestone many years ago by J. Matthew Jones.

associated with other smaller land shells that are still living. I have taken these land shells from such a rock, exposed only at low-water mark, in Bailey Bay. This large land shell was probably exterminated by the climatic changes due to the partial submergence of the land and consequent changes in the vegetation.

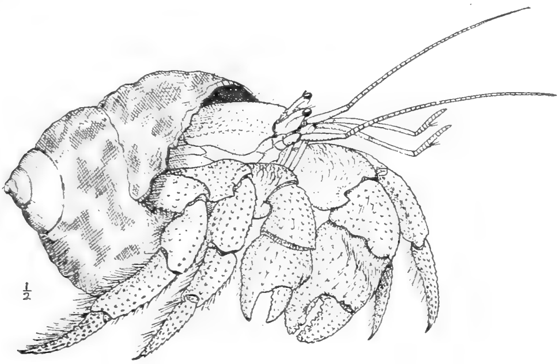


FIGURE 12.—Land Hermit Crab (*Cenobita diogenes*) in a fossil shell of *Livona pica*, ½ natural size. Drawn from life by A. H. Verrill.

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Art. XXXI.—*Some Boiling Point Curves;* by C. L. Speyers.

In several preceding papers* the equation

$$\frac{n}{N+n}=\frac{p-p'}{p}$$

was used to get at the molecular weights of liquids in homogeneous liquid mixtures and apparently with success, since the values so obtained were altogether reasonable.

On the other hand, knowing the molecular aggregations of the constituents in a homogeneous mixture of two liquids, it is possible to plot the boiling point curve of such a mixture.

For example, the boiling point curve under 760^{mm} Hg of a mixture of carbon tetrachlorid and benzene is calculated in the following way. The molecular weights of these liquids are probably normal. Wherefore, since $N+n=100$, the above equation becomes the equation to a straight line for each constituent and the vapor-pressure plot of the mixture is a straight line which has the vapor-pressures of the two pure constituents for its terminals. Fig. 1 shows the vapor-pressure plots of the

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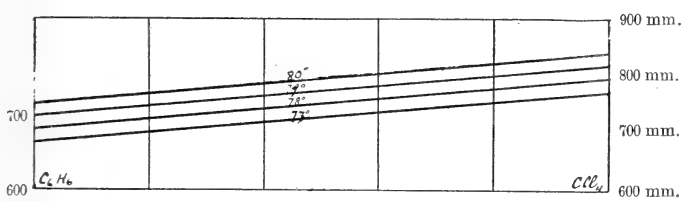

mixture at different temperatures. The abscissæ give the molecular percentages of carbon tetrachlorid; the ordinates give the pressure in mm Hg. The data were taken from Winkelmann.† At 81° the vapor pressures of carbon tetrachlorid and of benzene are both above 760^{mm} and at 76° their vapor pressures are both below 760^{mm}, so that the boiling temperature of this mixture lies between 76° and 81°. Laying off the compositions given by the several lines at the points where they intersect the horizontal pressure line of 760^{mm}, the points shown by x in fig. 2, plot I, are obtained, giving the theoretical

* Journ. Phys. Chem., ii, 347, 362, 1898; Journ. Am. Chem. Soc., xxi, 282, 725, 1899.

† Handb. d. Phys., II^2, 812, 814.

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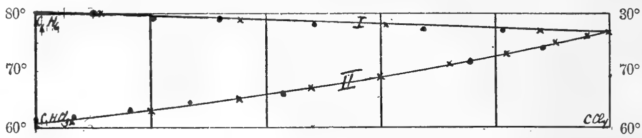

boiling point plot. The data recently obtained by Haywood* are shown by dots.

The boiling point curve for a mixture of chloroform and carbon tetrachlorid has been plotted, plot II of fig. 2, under the assumption that these liquids have normal molecular weights in this mixture, an assumption which is allowable since each has a normal molecular weight in benzene.† The experimental values are given by Thayer‡ and marked as before by dots, the theoretical values being denoted by x. The agreement is good except at the beginning, but Thayer's chloroform boiled at a considerably higher temperature than that given by Winkelmann quoting Regnault.

The boiling point curve for a mixture of benzene and chloroform has been plotted in fig. 3, the theoretical values and the

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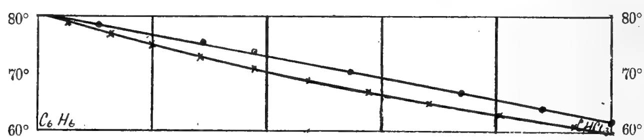

experimental values by Haywood‡ are marked as in fig. 2. The agreement is not good, but when a correction is made for the boiling point of chloroform, the agreement becomes better.

A more complicated boiling point curve is that of the mixture of benzene and ethyl alcohol. From Lehfeldt's data§ it seems probable that the molecular weights of both alcohol and of benzene are quite complex in this mixture. The temperature of Lehfeldt's experiments was 50° C., so that to use the values obtained at this temperature at a so much higher temperature as the boiling temperature of the mixture means to introduce an error, but the error seems to be inappreciable. The curve is shown in fig. 4, the same marks being used to distinguish between theory and observation as before, the

* Journ. Am. Chem. Soc., xxi, 994, 1899.
† Journ. Phys. Chem., ii, 347, 1898; Journ. Am. Chem. Soc., xxi, 282, 1898.
‡ Journ. Phys. Chem., iii, 317, 1899.
§ Phil. Mag., xlvi, 42, 1898.

observed values being those of Thayer.* The agreement is fair but can be improved. Referring to the figures of a preceding paper†, it may be noticed that in the toluene and alcohol mixture, the molecular weight of each solute approaches the normal value when the mixture is dilute with respect to that solute, but that in the benzene and alcohol mixture, the molecular weight of each solute keeps very high even when the solution is dilute with respect to that solute. Moreover that two observations on the vapor pressure of benzene point to a normal molecular weight for alcohol in dilute solution, but since these observations are so far from the others, at the time of writing the paper they could not be given any weight. Not so now. Thayer's data point very directly to these two observations being much nearer the truth than the neighboring ones. Wherefore it seems allowable to assume that the molecular aggregation of ethyl alcohol in benzene is about the same as in toluene and that the molecular aggregation of benzene in ethyl alcohol is about the same as that of toluene in ethyl alcohol. Values calculated on this assumption are marked by 1 in fig. 4.

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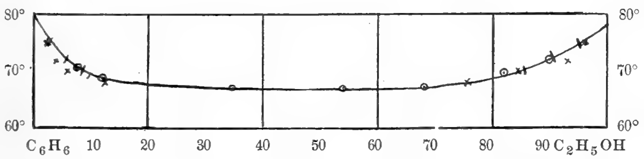


When the two constituents of homogeneous liquid mixtures have normal molecular weights for all concentrations, the boiling point curves will be straight lines when

$$\frac{dp_2}{dt_2} = \frac{dp_1}{dt_1},$$

where p_1, p_2, denote the vapor pressures of the two constituents and t_1, t_2, denote the corresponding temperatures. When

$$\frac{dp_2}{dt_2} > \frac{dp_1}{dt_1},$$

then the boiling point curve is convex towards the axis of abscissæ provided $p_2 > p_1$, but when $p_2 < p_1$, then the boiling point curve is concave towards this axis.

In no case should a mixture have a minimum boiling point when both constituents have normal molecular weights at all

* Journ. Phys. Chem., ii, 382, 1898.

† Speyers, Journ. Am. Chem. Soc., xxi, 282, 1898.

concentrations. Only when one or both constituents have abnormal molecular weights in a mixture, can the mixture have a minimum boiling point. But even then the mixture need not have a minimum boiling point. For when the vapor pressures of the two pure constituents are very different then, if the constituent with higher vapor pressure is the associated one, the vapor pressure of the other constituent may not be high enough at any concentration to prevail over the diminishing vapor pressure of the associated constituent. On the other hand, when the constituent with lower vapor pressure is the associated one, then a minimum boiling point is to be expected even though the vapor pressures of the two pure constituents may be very different. Yet it is possible in this case also that the mixture should have no minimum boiling point.

When the two constituents are both associated, then the mixture should have a minimum boiling point in general, but not always, for it is possible for the associating powers of the two constituents to be alike, in which case a change in concentration would make no difference in the numerical value of $n/(p-p')$ and equation 1 would still remain the equation to a straight line.

Equation 1 thus accounts for the boiling point curves of every mixture for which the partial pressures of the constituents are known at some one temperature not very far from the boiling temperature of the mixture under consideration.

Rutgers College, Feb. 3d, 1900.

ART. XXXII.—*The Action of Ammonium Chloride upon Natrolite, Scolecite, Prehnite and Pectolite;* by F. W. CLARKE and GEORGE STEIGER.

IN our last paper upon the ammonium chloride reaction,* we showed that analcite and leucite, when heated to 350° with this reagent in a sealed tube, both yielded the same compound, ammonium leucite, $NH_4AlSi_2O_6$. We also showed that the reaction was not limited to these minerals, but that it was fairly general in character; and that with other species analogous results could be obtained. We now have data relative to four more minerals, and these exhibit a range of variation which well illustrates the availability of the method for investigations into the chemical constitution of silicates. Three of the species now studied have previously been regarded by one of us as analogous in structure, provided that all or part of their *water* can be interpreted as constitutional; and the formulæ assigned were as follows:

Scolecite	$Al_2(SiO_4)_3CaH_4 . H_2O$
Natrolite	$Al_2(SiO_4)_3Na_2H_4$
Prehnite	$Al_2(SiO_4)_3Ca_2H_2$

Two of these formulæ must now be abandoned, because of the experimental evidence which we have obtained. We may first study the three species individually.

Natrolite.

In our former paper we reported a crude, preliminary experiment made upon impure, yellowish natrolite from Aussig in Bohemia. After heating with ammonium chloride in a sealed tube and subsequent leaching with water, 17·56 per cent of soda was extracted, and in the residue 8·29 per cent of ammonia was found. Natrolite, therefore, was a suitable mineral for further investigation; and our expectations regarding it have been fully confirmed.

The material available for our new experiments came from the well known locality at Bergen Hill, New Jersey, and consisted of a mass of slender needles densely matted together. Part of the uniform, ground sample was analyzed, with fractional determinations of the water, and part was used for the sealed tube experiments, precisely as in the research upon analcite and leucite. Three of these experiments were made; and in each case the natrolite was mixed by grinding in an agate

* This Journal, February, 1900.

mortar with four times its weight of dry ammonium chloride, after which it was heated to 350° in the sealed tube. Even during the grinding a slight reaction took place, and a distinct smell of ammonia was given off by the mixture. With pectolite the same smell was perceived. The three experiments may be summarized as follows:

A. Heated 11 hours. Upon leaching, 14·89 per cent of soda and 1·20 of lime were extracted. In the residue 9·26 per cent of ammonia was found.

B. Heated 9 hours. Leach not examined. 9·26 of ammonia in residue. The complete analysis of the residue is given farther on.

C. Heated 3 hours. 14·09 per cent of soda and 0·20 of lime were extracted. The residue contained 8·87 per cent of ammonia. In this instance the heating was relatively brief, in order to learn whether its duration could be advantageously lessened. The reaction was evidently less complete than in experiments A and B.

In the subjoined table we give first the analysis of the natrolite itself, and then that of the leached residue from experiment B. In the latter we found that 0·86 per cent of silica was soluble in sodium carbonate solution; and that soda and lime remained corresponding to 4·61 per cent of the original mineral. Deducting these impurities, together with the 0·42 per cent of hygroscopic water, and recalculating to 100 per cent, we get the *reduced* composition of the residue. In the last column is given the calculated composition of an anhydrous ammonium-natrolite, $(NH_4)_2Al_2Si_3O_{10}$. This compound has evidently been formed to an extent represented by over 94 per cent of the leached natrolite residue. The agreement between theory and even the unreduced analysis is practically conclusive on this point.

	Natrolite found.	Residue found.	Residue reduced.	$(NH_4)_2Al_2Si_3O_{10}$ calculated.
SiO_2	46·62	53·71	53·86	54·06
Al_2O_3	26·04	29·94	30·52	30·43
CaO	1·48	·34	----	----
K_2O	none	----	----	----
Na_2O	15·67	·37	----	----
NH_3	----	9·26	9·85	10·14
H_2O at 100°	·39	·42	----	----
H_2O above 100°	10·18	5·94	5·77	5·37
	100·38	99·98	100·00	100·00

It may not be superfluous to note that the water given in the last two columns represents the difference between ammonia and the hypothetical ammonium oxide which has replaced soda.

Two other experiments upon natrolite remain to be noticed. First, the fresh mineral was boiled for 15 minutes with a 25 per cent sodium carbonate solution; 0·72 per cent of silica dissolved. Similar treatment of ignited natrolite took out 0·62 per cent. No silica is split off by ignition. Ammonium-natrolite before ignition yielded 0·85 per cent of soluble silica, and after ignition 0·86 per cent. Here again no silica had been split off from the molecule, and practically none was liberated by the action of the ammonium chloride upon the natrolite. A simple, direct substitution of ammonium for sodium had occurred.

Scolecite.

On account of the well-recognized analogy between natrolite and scolecite, the latter mineral seemed to be peculiarly worthy of examination. The specimen at our disposal was a mass of stout, radiating needles, which was collected by one of us at Whale Cove, on the island of Grand Manan, New Brunswick. Scolecite, we believe, has not hitherto been recorded from this locality; and on this account alone the material deserved attention.

Three sealed tube experiments were carried out, essentially as in the case of natrolite, as follows:

A. Heated 10 hours at 350°. 13·74 per cent of lime and 0·35 of soda were taken out. The residue contained 8·78 per cent of ammonia.

B. Heated 10 hours at 370°. 12·97 of lime and 0·22 of soda were extracted. 8·48 per cent of ammonia in the residue. On account of the excessive temperature of this experiment, some reversion of the converted material had taken place.

C. Heated 5 hours at 340°–350°. Leach not studied. 8·91 per cent of ammonia in residue.

Analyses of the scolecite and of residues B and C are given below. The less perfect transformation in the case of B is evident.

	Scolecite.	Residue B.	Residue C.
SiO_2	45·86	53·39	53·69
Al_2O_3	25·78	30·51	30·50
CaO	13·92	·62	·42
Na_2O	·41	undet.	·29
NH_3	----	8·48	8·91
H_2O at 100°	·40	·74	·12
H_2O above 100°	13·65	6·28	6·52
	100·02	100·02	100·45

The product of the reaction is plainly the same as that obtained from natrolite, and the identity in type of the two

species is perfectly clear. This fact is further emphasized by an experiment upon the solubility of silica. The fresh scolecite gave up 0·36 per cent of silica to sodium carbonate solution, and the ignited mineral yielded only 0·50 per cent. Again, natrolite and scolecite behave in the same way.

Upon both minerals fractional determinations of the water were made, and the amount lost at each temperature was noted. The results, expressed in percentages of the original minerals, were as follows:

	Water lost.	
Temperature.	Natrolite.	Scolecite.
100°	·39	·40
180°	·40	·52
250°	·37	4·76
350°	8·51	·55
Incipient redness	·72	7·72
Full redness	·12	·04
Over blast	·06	·06
	10·57	14·05

Scolecite contains one more molecule of water than natrolite, and that amount, one-third of its total, seems to go off at a lower temperature than the other two molecules. Otherwise the two series of experiments are probably not far apart, and they indicate that the water is in neither case constitutional. The same conclusion is suggested by the existence of the anhydrous ammonium compound, the three formulæ being as follows:

Scolecite	$CaAl_2Si_3O_{10}.\ 3H_2O$
Natrolite	$Na_2Al_2Si_3O_{10}.\ 2H_2O$
Ammonium natrolite	$(NH_4)_2Al_2Si_3O_{10}$.

The parallelism is complete; and all three compounds are evidently salts of an acid $H_8Si_3O_{10}$, which is probably orthotrisilicic acid, $Si_3O_2(OH)_8$. The second anhydride of this acid, $H_4Si_3O_8$, would be the ordinary trisilicic acid of orthoclase and albite; a relation which is certainly suggestive. We do not, however, care to enter upon the question of chemical structure in this paper, and we therefore leave the subject for fuller consideration at some future time. It is clear, however, that orthosilicate formulæ for natrolite and scolecite must be discarded.

Prehnite.

The prehnite taken for examination was an old specimen from Paterson, New Jersey. The analysis, with fractional water determinations, is given below.

Analysis.	
SiO_2	42·31
Al_2O_3	19·95
Fe_2O_3	6·20
FeO	none
CaO	26·63
H_2O	5·02
	100·11

Fractional water.	
At 100°	·21
At 180°	·18
At 250°	·10
At 350°	·11
Incipient red heat	·28
Full red heat	4·05
Over blast	·09
Total	5·02

With sodium carbonate solution, 0·38 per cent of silica was extracted from the fresh mineral. From the ignited prehnite, 1·22 per cent was taken out. Very little silica, therefore, is liberated by ignition.

Two determinations were made of the action of ammonium chloride, as follows:

A. Heated 8 hours. On leaching with water, 1·31 per cent of lime and 0·17 of alumina dissolved.

B. Heated 12 hours. 1·41 per cent of lime was extracted, and in the washed residue 0·22 per cent of ammonia was found.

Prehnite, therefore, differs widely from natrolite and scolecite in its behavior with ammonium chloride. Very little action takes place, even upon long heating to 350° in a sealed tube, and practically no ammonia is absorbed. The water is more firmly held than was the case with the other two minerals, and is almost certainly to be regarded as constitutional. The orthosilicate formula for prehnite is unaffected by these results, and may stand as fairly probable. Prehnite cannot be correlated with natrolite and scolecite on any basis of similar chemical structure.

Pectolite.

In the first paper of this series* we described a number of experiments upon pectolite, in which we showed that it was almost undoubtedly a metasilicate; but the action of ammonium chloride upon it was neglected, as having been studied already by Schneider and Clarke.† In their experiments upon pectolite from Bergen Hill, which was nearly identical in composition with our sample, a triple heating in an open crucible with ammonium chloride removed 20·50 per cent of lime, 6·95 of soda, and 0·54 of manganous oxide; or about two-thirds of the total amount of bases present. In our last paper we reported a preliminary experiment by the sealed tube method, and found that 20·72 per cent of lime and 6·46 of

* This Journal, October, 1899.

† Bulletin No. 113, U. S. Geological Survey, p. 34.

soda were taken out, while 1·44 of ammonia was retained by the residue. Here again two-thirds, approximately, of the bases, had been converted into chlorides by the reaction. The open crucible and the sealed tube gave essentially the same results, although the retention of ammonia was not noticed by Schneider and Clarke.

In order to obtain further light upon pectolite we continued our experiments with the sealed tube method, and have obtained very variable results. All of the heatings with ammonium chloride were conducted at 350°, and the pectolite used was from the same Bergen Hill specimen which served us for our previous work. Our data are as follows; including for convenience of comparison the preliminary experiment which was cited above.

A. Heated 6 hours. On leaching, 20·72 per cent of lime, 6·46 soda, and 0·11 alumina dissolved. The residue contained 1·44 per cent of ammonia.

B. Heated 6 hours. 20·10 per cent lime and 5·80 of soda extracted. 1·45 per cent ammonia in the residue. The residue was also examined for silica soluble in 25 per cent sodium carbonate solution (on 15 minutes boiling), and 43·38 per cent was found.

C. Heated 6 hours. Soluble portion neglected. The residue contained 2·23 per cent of ammonia and 61·79 per cent of soluble silica. The full analysis of this residue is given later.

D. Heated 10 hours. A complex breaking up of the pectolite took place, and leaching with water extracted the following percentages:

SiO_2	5·43
Al_2O_3	·22
CaO	28·20
MnO	·23
Na_2O	8·29

The residue from this leaching contained 39·63 of soluble silica, but ammonia was not determined.

These results are so irregular that definite conclusions can hardly be drawn from them. A and B agree fairly with each other, and also with the earlier work of Schneider and Clarke. C contains more ammonia, but differs widely from B as to the amount of soluble silica in the residue. D, which represents a long heating, indicates a more complete reaction than was observed in either of the other cases.

An ammonium compound, however, is evidently formed during the reaction, although its precise nature cannot be determined from the evidence now in hand. Something may be inferred from the following figures, which are to be summarized thus: First, we reproduce from our earlier paper

the analysis of the pectolite itself. Secondly, we give the analysis of the insoluble residue obtained in experiment C. The third column of figures is obtained by subtracting from the second column 61·79 of soluble silica and 1·18 of hygroscopic water, and recalculating the remainder to 100 per cent. The fourth column contains the molecular ratios calculated from the third.

	Pectolite.	Residue found.	Residue reduced.	Ratios.
SiO_2	53·34	75·98	37·74	·629
Al_2O_3	·33	·08	·19	·002
CaO	33·23	9·56	25·43	·454
MnO	·45	·24	·63	·009
Na_2O	9·11	1·84	4·89	·079
NH_3	----	2·23	5·93	·349
H_2O at 100°	·27	1·18	----	
H_2O above 100°	2·70	9·47	25·19	1·399
CO_2	·67	----	----	
	100·10	100·58	100·00	

These ratios roughly suggest the formation of a salt approximating in composition to the formula $R'_2Ca_2Si_3O_9.6H_2O$, in which R′ is about two-thirds ammonium and one-third sodium. Pectolite itself has the formula $NaHCa_2Si_3O_9$; so that the existence of a hydrous ammonium pectolite is indicated; a conclusion which is probable, but not proved. The reaction between pectolite and ammonium chloride is possibly simple at first, but followed by or entangled with secondary changes which obscure the results. The experiments are interesting, however, as showing how widely pectolite differs from the other minerals which we have studied, as regards the ammonium chloride reaction. The general investigation is to be continued, and we hope to take up next the more important lime-soda zeolites.

Laboratory U. S. Geological Survey,
Washington, March 1, 1900.

ART. XXXIII.—*Siliceous Calcites from the Bad Lands, Washington County, South Dakota;* by S. L. PENFIELD and W. E. FORD. With Plate V.

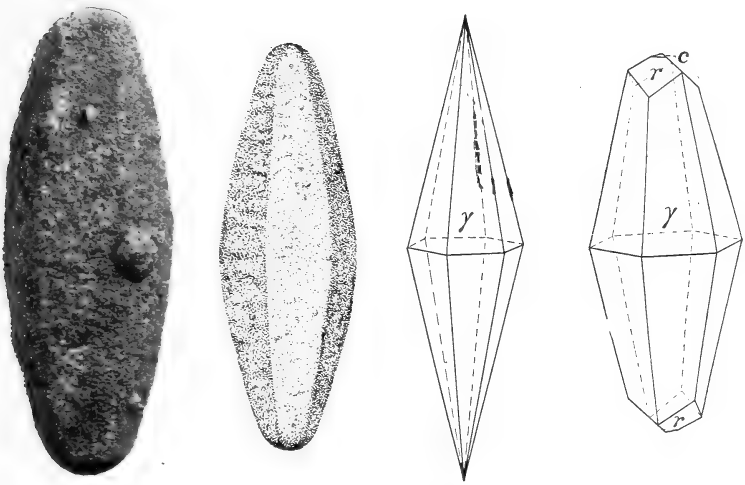
THE siliceous calcites from Fontainebleau, sometimes called Fontainebleau limestone, are well known objects to the mineralogist, and specimens are to be found in many cabinets. They consist of calcite enclosing from fifty to sixty per cent of sand, and were early described by Lassone* and Haüy.† Specimens of almost the same character as those from Fontainebleau have recently been found in the Bad Lands of South Dakota, and have been sent to New Haven for examination by L. W. Stilwell of Deadwood, South Dakota, and Mr. Geo. L. English of New York. Our attention has also been called to the occurrence by Prof. E. H. Barbour of Lincoln, Nebraska, and, as he has expressed his intention to visit the locality, he will doubtless be able to furnish interesting information concerning the mode of occurrence of the crystals. The specimens sent by Mr. English consist of a representative suite of handsome cabinet specimens for the Brush Collection, together with abundant material for study, and thanks are due to him for his generosity. A quantitative examination of a typical specimen was made, and indicated that the material consists of about forty per cent of calcite enclosing sixty per cent of quartz sand. In the region of the Bad Lands of Dakota, whence the crystals come, the White River sandstone is a very abundant rock and consists of sand grains cemented together by calcareous material. Evidently the crystals in question represent a phase of sand cementation in which the crystalline form of the calcite is preserved. This kind of cementation might take place, for example, in a sand deposit wet with water carrying calcium carbonate in solution. The calcite crystallization may be conceived to go on, until crystals of a certain size have been produced, the calcite material growing about and enclosing the sand grains, and then it seems necessary to consider that the crystallization ceased, owing to changed conditions, for otherwise an ordinary solid sandstone with calcareous cement would result. The partial wearing away of such a sand deposit in which crystallization had taken place would then expose the crystals.

An interesting feature of the siliceous calcites from the new locality is the peculiar shape of the crystals. The crystals from Fontainebleau have the shape of the rhombohedron, *f*, $02\bar{2}1$, -2, fig. 5, p. 263 of Dana's Mineralogy, which is a

* Mem. d. l'acad. royal. Paris, 1775, p. 65.
† Traité de Mineralogie, vol. i, p. 424, 1822.

common and typical development for calcite. Those from the Bad Lands, however, are steep hexagonal pyramids, somewhat barrel-shaped and with rounded ends. Fig. 1, from a photograph, represents a complete crystal, natural size, and gives a good idea of the general shape of the specimen and the character of the grain. As usual with photographic representations of crystals, however, the edges are not very well defined, and the pen and ink sketch, fig. 2, has been introduced to bring out with greater distinctness the hexagonal character. In a rhombohedral species a hexagonal pyramid must be a pyramid of the second order, and that the crystals from the Bad Lands are of this character may readily be told by exam-

1 2 3 4



ining their ends before a strong light, when, on turning the crystals, it will be found that the flash or reflection from the rhombohedral cleavage of the calcite is only caught when the alternate edges of the pyramid are toward the light. With the aid of a lens no difficulty is experienced in observing the calcite, filling the interstices between the quartz grains, and in detecting its cleavage. Pyramids of the second order are seldom observed in calcite, even as small faces in complex combinations, while crystals showing the hexagonal pyramid alone, or with but slight modifications are exceedingly rare. Calcite crystals from Rhisnes, Belgium, having the pyramid γ, $8{\cdot}8{\cdot}\overline{16}{\cdot}3$, as the prevailing type and only slightly modified by other forms have been described by Cesàro,* and the crystals from the Bad Lands are undoubtedly rounded modifications of this same

* Mem. de l'acad. roy. d. Belgique, xxxviii, p. 1, 1886.

rare pyramidal form. Fig. 3 represents the pyramid $8\cdot8\cdot\bar{16}\cdot3$, without modification, and if the siliceous calcites were originally of this shape it is evident that by corrosion and weathering the acute terminations would rapidly become rounded, while by a little wearing away of the horizontal middle edges a barrel-shaped form similar to fig. 2 would result. Fig. 4 represents a combination of the pyramid γ, $8\cdot8\cdot\bar{16}\cdot3$, with the rhombohedron r, $10\bar{1}1$ and the base c, 0001, described and figured by Cesàro, and by only a very little corrosion and weathering of such a combination a rounded shape like fig. 2 would result.

The crystals from the Bad Lands occur at times singly, but more often grown together in groups, the latter at times of considerable size. The accompanying half-tone plate will give some idea of the size and character of the specimens. The crystals have evidently formed in a bank or deposit of stratified sand, for, as shown by the upper, left hand crystal and the central group in the plate, the original bedding of the deposit may be detected running through the crystals in directions which have no relation to their crystallographic symmetry. The central group resembles a somewhat weathered clay-stone concretion, or the sculpture forms resulting from the corrosion of some stratified sandstones; it has, however, the crystalline character of the other specimens, although the shapes of the crystals have been nearly obliterated by excessive weathering. The sand in the specimens is, for the most part, of a nearly uniform grain, the grains averaging from about $\frac{1}{3}$ to $\frac{1}{2}^{mm}$ in diameter, and being well rounded. Occasionally there occur, imbedded along with the finer sand, large, rounded grains, true quartz pebbles, measuring as much as a centimeter in diameter. One specimen, the lower right hand one of the plate, is a veritable pudding stone, yet in spite of the coarseness of grain the pyramidal forms are well developed. The crystals have a gray color almost exactly like that of the Fontainebleau specimens.

Sheffield Laboratory of Mineralogy and Petrography,
Yale University, New Haven, April, 1900.

ART. XXXIV.—*Studies in the Cyperaceæ;* by THEO. HOLM. XII. Segregates of *Carex filifolia* Nutt. (With eight figures in the text.)

WHILE engaged in a study of the alpine flora of the Rocky Mountains in Colorado last summer, we noticed a small *Carex*, which showed such a striking resemblance to *Elyna spicata*, that it required a careful analysis of the flower to decide whether it was this plant or, really, a *Carex*. It was unlike any other which we had seen heretofore in the mountains, but it occurred so abundantly on some bald mountain tops, that we never suspected it to be a "species nova." However, when we commenced to work up the material, it was soon learned that our plant was an old acquaintance, but that it had been placed under *Carex filifolia* Nutt. as a variety: *miser* (sic!) Bail. It never occurred to us that this plant could be in any way a form or variety of *C. filifolia*, and since the so-called variety "valida" of this same species from lower elevations was also in our collection, we felt induced to study them in order to find out how far they were related to each other. The result of our investigation is, that we can by no means look upon these plants as representing one species, nor being varieties, since they exhibit not a few distinct morphological characters, besides that, we have, also, found some important differences in their anatomical structure.

In later years anatomical studies have become very useful not only to the classification of plants in general, but also in view of the species themselves. And in a genus as large as *Carex* the morphological characters are often so indistinct and unimportant that it seems quite necessary to take the two together. The anatomical literature already possesses several works upon the structure of *Carices*, which may be seen from our references in previously published articles in this Journal. In the present case it is our intention to show how very important distinctions may be drawn from the structure of species which, viewed morphologically, were once considered as only one type with two varieties.

As regards *Carex filifolia* Nutt. this species is by Professor L. H. Bailey* placed under the *Sphæridiophoræ* of Drejer,† as a member of Tuckermann's "*Filifoliæ*,"‡ and next to *Carex scirpoidea* Michx. However, it is readily seen by compar-

* Bailey, L. H.: A preliminary synopsis of North American Carices (Proceed· Am. Acad. Arts and Sciences, 1886, p. 122).

† Drejer, S.: Symbolæ Caricologicæ. Kjöbenhavn, 1844, p. 9.

‡ Tuckermann, Edw.: Enumeratio methodica Caricum quarundam. 1843.

ing these two species, that the latter does not show any relationship to *C. filifolia*, but that it may be more naturally placed among the "*Montanæ*" of Fries,* and as one of the "*formæ hebetatæ*" of that section, as already pointed out by Drejer (l. c.). *Carex filifolia* is, on the contrary, one of the *Filifoliæ* Tuckm., and constitutes together with our *C. elynoides*, the only representatives of this group in North America. But it is, on the other hand, not so very certain whether the "*Filifoliæ*" are really to be placed under the *Sphæridiophoræ*, at least not if we emphasize this section as it was originally proposed by Drejer. This author does not attribute such characters to the *Sphæridiophoræ* as are included by Professor Bailey (l. c.).

Drejer does not speak of a "perigynium, firm or hard in texture, hairy or scabrous," but "perigynium membranaceum, pube hirsutie vel tomento vestitum," of which only the first character, the membranaceous perigynium (utriculus) is applicable to *C. filifolia*. Moreover, Drejer describes the bracts as "membranaceæ nervo dorsali excurrente herbaceo," which is not recognized by Professor Bailey, and which does not apply to *C. filifolia* either. The description of the utriculus: "rostro apice subbilobo" by Drejer is by Professor Bailey translated as "bifid." In other words, the *Sphæridiophoræ* of Drejer are not identical with the section of the same name by Professor Bailey. Therefore, Professor Bailey does not hesitate to place the broad-leaved, stoloniferous *Carex scirpoidea* Michx. side by side with *C. filifolia*, to which it shows no resemblance whatever.

The systematic position of Tuckermann's "*Filifoliæ*" yet remains to be settled, and these, no doubt, represent a group just as peculiar and isolated from the other *Carices* as is the case with the remarkable *Carex Fraseri* Andr. We must at present content ourselves in recognizing the *Filifoliæ* as a section rather than a subsection, and it may be of some service to further studies, when we in the following pages present a brief discussion of a species, which seems to be very closely related to *C. filifolia*, while eliminating another, which was formerly considered as an ally of this species. These segregates of *Carex filifolia* Nutt are:

Carex elynoides Holm (fig. 1).
(*C. filifolia* Nutt. var. *miser* Bail., not *C. miser* Buckl.)

Rhizome densely cespitose; culm 5 to 8^{cm} high, stiff, terete, sulculate, glabrous; leaves for the most part longer than the

* Fries, Elias: Summa vegetabilium Scandinaviæ. Upsala, 1846. Sectio I, p. 70.

FIGURE 1.—*Carex elynoides*, fruiting and flowering specimen; natural size.
FIGURE 2.—*Carex oreocharis*, natural size.
FIGURE A.—Scale of the male flower of *C. elynoides*, enlarged.
FIGURE B.—Scale of the female flower of same, enlarged.
FIGURE C.—Scale of the male flower of *C. oreocharis*, enlarged.
FIGURE D.—Scale of the female flower of same, enlarged.
FIGURE E.—Utriculus of same, enlarged.
FIGURE F.—Utriculus of same, enlarged.

culm, stiff, filiform, scabrous, their sheaths light-brown, persisting, not fibrillose; spike one, androgynous, few-flowered, 1 to $1\frac{1}{2}^{cm}$ long; scales of male flowers ovate-lanceolate (fig. A), reddish-brown, the midrib pale, not excurrent; scales of female flowers (fig. B) broadly obovate, minutely pointed from the excurrent midrib, reddish-brown with narrow membranaceous, hyaline margins; female flowers three or four; utriculus membranaceous (fig. E), obovoid, obtusely triangular in cross-section, with a distinct obliquely cut beak, ciliate above, at maturity longer than the scale; nerves two, not distinct; caryopsis obovate, sharply triangular in cross-section; rhacheola none; stigmas three.

Habitat: Mountains near Pagosa Peak, southern Colorado, in extensive turf-like patches on bald tops, at 12,000 feet (C. F. Baker). Very abundant on dry rocks at 12,000 feet: Mt. Kelso and Mt. Elbert, middle Colorado (the author).

Differs from *C. filifolia* Nutt., especially in its dark, reddish-brown scales, which are narrower, and by the utricle, which is relatively longer, attenuated at both ends and glabrous excepting the ciliate apex. Boott's *C. Lyoni* is distinct from this by its creeping rhizome, broader leaves and linear-lanceolate, bidentate utricle. *Carex affinis* R. Br., which does not seem to be well understood, has been referred to *C. filifolia* by Boott, but later on to *C. obtusata* Liljebl. by the same author. Professor Bailey has, also, referred it to *C. obtusata*.*

Carex oreocharis Holm (fig. 2).
(*C. filifolia* Nutt. var. *valida Olney*, not *C. valida* Nees.)

Rhizome cespitose, culm from 10 to 20^{cm} high, stiff, somewhat robust, terete, sulculate, glabrous; leaves shorter than the culm, 5 to 10^{cm} long, narrowly conduplicate, scabrous along the margins; leaf-sheaths dark-brown, almost black, persisting, slightly fibrillose; spike one, androgynous; male portion many-flowered, clavate, 1 to $1\frac{1}{2}^{cm}$ long, whitish and shining; scales oblong-lanceolate (fig. C), the midrib not excurrent; pistillate flowers 3 to 7; scales (fig. D) ovate-acuminate sharply pointed, the lowest one leaf-like with a distinct awn from the excurrent midrib; utriculus membranaceous, broadly elliptic (fig. F), obtusely triangular in cross-section, with a short beak, minutely pubescent, two-nerved, but the nerves not distinct; at maturity the utricle is longer than the scale, excepting the lower one; caryopsis nearly globular, obtusely angled; rhacheola distinct as in *C. filifolia*; stigmas three.

* Bailey, L. H.: Studies of the types of various species of the genus *Carex*. (Mem. Torr. Bot. Club, vol. i.)

Habitat: Near Denver, Colorado (E. L. Greene). Common on dry rocks in the Aspen-zone at Long's Peak, middle Colorado, at 8,600 feet (the author).

Differs from *C. filifolia* by its broader leaves, and more robust culm, but especially by the pointed scales and the pubescence of the utricle.

These morphological characters may be supplemented by some others, derived from the internal structure of these species together with *C. filifolia* Nutt., in order to draw the specific distinction still more completely. The anatomical structure is as follows:

The root.

Inside the epidermis, which shows the usual structure, is a hypoderm of a single stratum large, thin-walled cells in *C. filifolia*, or of thick-walled in *C. oreocharis*, or finally of three to four thin-walled strata in *C. elynoides.* The cortex is developed as two very distinct zones, of which the outer consists of stereïds, the inner one, on the contrary, of mostly thin-walled parenchyma, which shows the characteristic tangential collapsing, excepting the innermost stratum, which borders on endodermis. The thickness of these two layers seems to vary in these species, and we notice for instance in *C. filifolia* that the stereomatic portion consists of nine strata, while there are only four in the two other species. Moreover, in *C. filifolia* the outer cortex is interspersed with rays of thin-walled parenchyma, which do not show any signs of collapsing. The inner cortex is thin-walled throughout in *C. elynoides* and *C. filifolia*, but in *C. oreocharis* only the five or six inner strata are thin-walled, the outermost four or five being distinctly thickened, but not, however, to such an extent as the stereomatic part of the cortex. The endodermis is thick-walled in *Carex filifolia* and *C. elynoides*, but not so in *C. oreocharis.* By examining the pericambium we find this as only one stratum in all three species, thin-walled in *C. elynoides* and *C. filifolia*, but thickened in *C. oreocharis.* This tissue, the pericambium, is in *C. elynoides* interrupted by all the proto-hadrome vessels, but not so in the two other species; in one root of *C. filifolia*, for instance, six proto-hadrome vessels out of twenty-one had not broken through the pericambium, while in some thinner roots only one of these vessels out of sixteen bordered on endodermis. The leptome and the proto-leptome is very well developed in these species and arranged in alternation with the proto-hadrome. Some large vessels surround the innermost part of the central-cylinder, which is occupied by conjunctive tissue, especially thick-walled in *C. elynoides* and *C. filifolia.* In passing to examine

The stem,

this is terete and hollow in all three species, sulculate in *C. elynoides* and *C. filifolia*, smooth in *C. oreocharis;* a few curved prickle-like projections are observable in *C. filifolia*, but in the two other species the culm is glabrous. The cuticle is smooth and very distinct. Epidermis thick-walled, excepting those cells which contain the silicious cones, and which are observable outside the stereome. The stomata are level with the surrounding epidermis, and are not protected by any papillæ, nor are the subsidiary cells raised above the guard-cells themselves. In the sulculate stems the stomata are, furthermore, equally distributed outside the cortex, without being confined to the bottom of the furrows, or along the sides of them. The cortex consists of palisades, radiating towards the center of the stem and shows wide lacunes in *C. elynoides* and *C. oreocharis;* in *C. filifolia*, on the other hand, the palisade-tissue is very compact and persisting. The stereome is very thick-walled in *C. oreocharis*, but not so in the other species; it occurs as hypodermal groups accompanying the large mestome-bundles, besides that it also covers the hadrome-side of these, bordering on the pith; the smaller mestome-bundles have but very little stereome on either face, separated from epidermis by the palisade-tissue. All the mestome-bundles lie in one peripheral band, larger alternating with smaller ones; they are surrounded by a green, thin-walled parenchyma-sheath, inside of which we find the usual mestome-sheath, which is heavily thickened in *C. oreocharis*, less so in the other species. Some few strata of thick-walled mestome-parenchyma were observed between the leptome and hadrome at least in the larger bundles of all these species. The pith consists of a very thin-walled parenchyma which breaks down, leaving a wide cavity in the center of the stem. In comparing this stem-structure with that of the other *Cyperaceæ* in general, our species seem well characterized by possessing a terete and hollow stem, instead of a triangular and solid one as in the majority of the other species, at least in *Carex*.

The leaf

offers excellent characters by which these species may be readily distinguished from each other, and we find in *C. elynoides* exactly the same leaf structure as we have observed in *Elyna spicata*. The broadest leaf is possessed by *C. oreocharis* from an elevation of 8,600 feet, and the narrowest by *C. elynoides* from the high alpine slopes. The width of the leaf of *C. filifolia* from the foothills is intermediate between these two species. The leaf is not flat in any of these species, but

cylindric with a mediane groove in *C. elynoides*, and conduplicate in the others. There are no furrows on the dorsal face of the blade and no papillæ from epidermis protect the stomata; short, but pointed prickle-like projections from epidermis occur along the keel and the leaf-margins, but they are relatively few in number. The cuticle is very distinct, but not very thick, and it is perfectly smooth. Epidermis is thick-walled with the exception of the cone-cells, and viewed superficially we notice quite a considerable difference in the respective length of the cells outside the stereome and the palisade-tissue. In *Carex elynoides* and *C. oreocharis* the cells of epidermis outside the stereome are almost quadrangular with nearly straight radial walls, while they are rectangular with undulate walls in those strata which cover the mesophyll. Similar structure of epidermis is, as we remember, especially characteristic of the *Gramineæ*, in which, however, the short cells show often a stronger silicification than the others, besides they are frequently more or less fusiform in outline. In *C. filifolia* epidermis shows no such modification. Stomata are present on the lower surface outside the mesophyll and near the margins on the upper; they show the same structure as described above for the stem. The upper face of the blade shows an epidermis of larger cells, and one row of true bulliform cells were observed in *C. oreocharis*, just above the midrib; in the two other species the epidermis-cells are uniformly developed, none being bulliform, but we find in these two species a secondary epidermis of small cells, which is especially distinct above the midrib.

The mesophyll is developed in a very different manner in these species. In *C. oreocharis* it shows a distinct palisade-tissue, the cells of which are vertical on the blade; lacunes are to be found between the mestome-bundles, but they are not very wide and do not extend to epidermis. In *C. filifolia* the palisade-tissue is compact and borders on a large colorless tissue, which occupies the upper part of the leaf, and which is broken down into two large lacunes, separated from each other by a narrow layer of green mesophyll above the midrib. In the leaf of *C. elynoides* we find a relatively narrow palisade-tissue on the lower face of which several cells radiate towards the center of the mestome-bundles; the greater part of the upper face is occupied by an enormous mass of colorless tissue, which is partly broken down into a continuous, wide lacune. The stereome is more thick-walled in *C. filifolia* than in the other two species. It occurs as hypodermal groups on both faces of the blade, accompanying the larger mestome-bundles in *C. oreocharis*, while the smaller bundles are only supported by a

few stereome-cells on the leptome- and hadrome-side separated from epidermis by the palisade-tissue. In *C. elynoides* and *C. filifolia* the stereome on the hadrome-side is separated from the upper epidermis by the colorless tissue, even in the largest mestome-bundles. Common to all three species are two marginal, hypodermal groups of stereome on the upper surface of the leaf. The mestome-bundles occur as large and small ones, in regular alternation with each other. There is a thin-walled, green parenchyma-sheath and a mestome-sheath with thickened inner cell-wall in all three species; in *C. filifolia* and *C. oreocharis* there is, moreover, some few strata of thick-walled mestome-parenchyma between the leptome and hadrome, but not in *C. elynoides.* Tannin-reservoirs were not observed.

Utriculus.

The structure shows a thick-walled dorsal epidermis and from one to six strata of colorless parenchyma between this and the ventral epidermis; in *C. filifolia* the dorsal epidermis has developed a number of small, rounded, wart-like protuberances, besides many erect, sharply-pointed prickles, which abound near the apex of utriculus. Similar prickle-like projections are, also, observable in *C. oreocharis,* but they are not so numerous, and no wart-like protuberances were observed. In *C. elynoides* the utricle is almost wholly glabrous. Two mestome-bundles are developed in utriculus and they are supported by stereome, which, furthermore, occurs as isolated, hypodermal groups, about fifteen in each species.

The rhacheola

is very distinct in *C. filifolia* and *C. oreocharis,* and shows a very thick-walled epidermis, a compact cortex and three mestome-bundles near the center, each partly surrounded by groups of stereome. The rhacheola bears many pointed prickles near the apex, but in no case did we find any development of rudimentary leaves or flowers, which is, otherwise, not uncommon in *Carex,* though exceedingly rare in the monostachyous species.

In summarizing the structural characters which we have noticed in these three species of *Carex,* it seems as if these are very distinct anatomically, notwithstanding the fact that they are all inhabitants of a dry soil, though at different elevation. Among the most prominent characteristics may be recalled the constant interruption of the pericambium by the proto-hadrome in *C. elynoides,* while in the other species some of these vessels are separated from the endodermis; the large colorless, lacunous tissue in the leaves of *C. filifolia* and *C. elynoides* in con-

trast to *C. oreocharis*, where the lacunes are much narrower and located in the palisade-tissue itself; furthermore the well developed bulliform-cells in the latter species, while these are totally absent in the others.

There appears, thus, to be several both morphological and anatomical characters by which these three species may readily be distinguished from each other, and which, moreover, seem to justify the separation of these plants as independent species. It would hardly be natural to consider, for instance, *C. elynoides* as a merely alpine variety of *C. filifolia*, since the latter is often an inhabitant itself of the alpine regions without changing its usual habit to any considerable extent, at least not acquiring any of the peculiarities possessed by the former. As regards *C. oreocharis*, this cannot represent a variety either, inasmuch as it shows relationship to the "*Montanæ*" and may together with *C. scirpoidea* Michx. he counted among the "formæ hebetatæ" of this subsection.

Brookland, D. C., January, 1900.

ART. XXXV.—*Mineralogical Notes;* by AUSTIN F. ROGERS.*

1. Gypsum.—The gypsum crystals described in this paper were obtained by the writer at Lebo, Coffey Co., Kansas. They occur as isolated crystals and groups in Coal Measure shales at a "strip-pit" coal mine located at the edge of town.

Both simple and twinned crystals were found, but the latter are of especial interest because they appear to possess hemimorphic-orthorhombic symmetry rather than monoclinic. In this respect they resemble gypsum crystals described by Pirsson† from Girgenti in Sicily. Fig. 1, an orthographic

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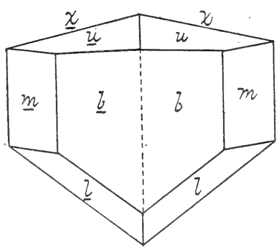

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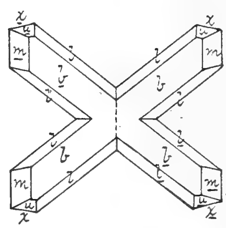

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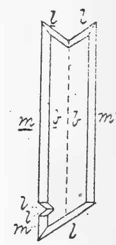


projection of one of the twins with the clinopinacoid (010) as the plane of projection bears a striking resemblance to Pirsson's figure, though some of the forms are different. The twinning plane and composition face is the ordinary one for gypsum, a (100) i-i. The following forms were observed :

$$m\,(110)\,I;\ b\,(010)\,i\text{-}\grave{\imath};\ l\,(111)-1;\ \chi\,(\bar{2}03)\,\tfrac{2}{3}\text{-}\bar{\imath};\ u\,(\bar{1}33)\,1\text{-}\breve{3}$$

The form $\chi\,(\bar{2}03)$ is given by Goldschmidt in his "Index der Krystallformen der Mineralien" in the list of uncertain forms. As the faces are rather dull a contact goniometer was used for the identification of the forms. The results are as follows:

		Limits.	Average.	Calculated.
$\chi \wedge \underline{\chi}\,(\bar{2}03 \wedge \underline{\bar{2}03})$	10 measurements	26°–27°	26° 28′	27° 00′
$u \wedge u\,(\bar{1}33 \wedge \bar{1}\bar{3}3)$	10 measurements	43° 20′–45° 30′	44° 25′	44°·48′

Some of the simple crystals are very flat by extension of l(111)−1. Fig. 2 represents a cruciform penetration-twin with the orthopinacoid (100) as twinning plane. Fig. 3 may be considered as the same with one part of the reversed crys-

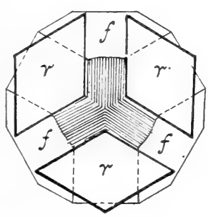
* Published by permission of the Director of the University Geological Survey of Kansas.

† L. V. Pirsson, this Journal, vol. xlii, pp. 407, 408, 1891.

tal wanting. Figs. 2 and 3 are orthographic projections with the pinacoid (010) as the plane of projection.

2. Calcite.—In homogeneous crystal aggregates composed of individuals in parallel position the individuals are usually similar in habit. Those in which the individuals are different in habit seem to be of rather rare occurrence. Our general mineralogical literature contains descriptions and figures of but few such. An aggregate of this kind composed of calcite crystals is represented in fig. 4, which is an orthographic projection with the basal pinacoid (0001) as the plane of projection. These specimens were collected by the writer (where they occur in cavities in limestone) at Argentine, Kansas. The crystal host, as it may be called, is light brown in color and exhibits the following forms, $r\,(10\bar{1}1)R$; $f\,(02\bar{2}1)$–2. Truncating the polar edges of r are pseudo-rhombohedral faces of the

4



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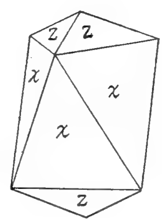


negative rhombohedron $-\frac{1}{2}$, formed by oscillatory combination of the latter form with the positive unit rhombohedron. On each of the r faces is placed a flat colorless calcite crystal with the forms, $r\,(10\bar{1}1)$; $e\,(01\bar{1}2)$ and an undetermined scalenohedron. The unit rhombohedron is the predominant form, while the negative rhombohedron and the scalenohedron which are not shown in the drawing, appear as very narrow faces the latter bevelling the basal edges of r. The superimposed crystals are distinct crystals and may easily be removed from their host without damage to either.

Another parallel aggregate composed of calcite crystals of different habit was found in limestone at Kansas City, Mo. On the top of the scalenohedron $v\,(21\bar{3}1)$ with its shorter polar edges truncated by $f\,(02\bar{2}1)$ is placed a unit rhombohedron of the same mineral, their apices coinciding. The scalenohedron is covered with a thin brownish film while the rhombohedron is colorless and perfectly transparent.

3. Calcite.—Occurring in chalk in the western part of Kansas along the Smoky Hill river in Logan, Gove and Trego Counties, are veins of calcite in which are cavities lined with

crystals of the same mineral. Several such specimens in the University of Kansas Museum, the exact locality of which is unknown, furnish the following notes. The crystals examined are of three different habits: (1) the form $e(01\bar{1}2)$-$\frac{1}{2}$, large crystals with faces striated parallel to shorter diagonal of the faces; (2) the form $f(02\bar{2}1)$-2, small to medium sized crystals; (3) the third deserves more detailed notice. These crystals average about 5^{mm} in diameter and present the following uncommon forms: $Z(02\bar{2}3)$-$\frac{2}{3}$ and $\chi(07\bar{7}2)$-$\frac{7}{2}$, represented in fig. 5. The faces are dull and a little rough so that no measurements were possible with the reflecting goniometer. Measurements with the contact goniometer were as follows:

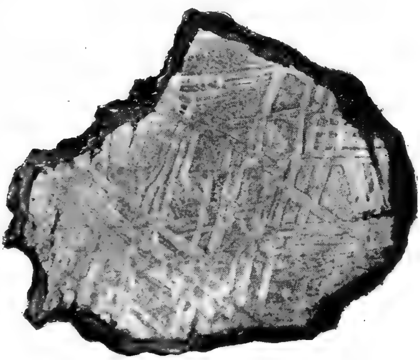
		Limits.	Average.	Calculated.
$Z \wedge Z\ (02\bar{2}3 \wedge 02\bar{2}3)$	6 measurements	56°–57° 30′	56° 35′	56° 50′
$Z \wedge \chi\ (02\bar{2}3 \wedge 07\bar{7}2)$	6 "	40° 30′–42°	41° 08′	40° 31′

The χ faces are triangular in shape and in consequence the embedded crystals with the Z faces partially concealed have somewhat the appearance of regular octahedra.

Mineralogical Laboratory, University of Kansas.

Art. XXXVI.—*The Hayden Creek, Idaho, Meteoric Iron;* by W. E. Hidden.

The mass of coarsely crystallized meteoric iron here described, was first brought to my notice by Mr. J. M. Parfet of Salmon City, Idaho. In a letter dated Oct. 3, 1895, he described its discovery as follows: "The piece of supposed meteoric iron, when first found, was just twice the size of the part I send you. It was kidney-shaped and in that condition would have been much more valuable (interesting), but the prospector, who found it at the bottom of a twelve-foot shaft, on Hayden Creek, Lemhi County, Idaho, just above the U. S.



Section of Hayden Creek Meteorite, actual size.

Agency ground, while prospecting for placer gold, wondered what he had found and went to work on it with a four-pound hammer. This he kept up at odd times for weeks while in camp, and the first time he came down to the agency shop, he laid it upon the lap of the anvil and with a fourteen-pound hammer succeeded in bending it one way, then turned it over and bent it the other; this he kept up until he broke it in two. Finding it was not a nugget of gold, he had no further use for it and I got it from him for a trifle. . . . . At the time it was broken the metal showed at the point of fracture to be almost silver-white and was quite pretty, but time has oxidized it considerably and it has lost its luster." (Signed) J. M. Parfet.

The above account sets forth the history of the smaller half of this meteorite. Since I recognized it at sight as true meteoric iron, and realized that half of it was missing or was probably in unappreciative hands, I at once began an inquiry for the missing part. Suffice it to say that it was, after many

months, traced to the Mineral Cabinet of Mr. Don McGuire of Salt Lake City, Utah; and was after much correspondence, secured by the writer. It is now intact and has not as yet been analyzed or very critically studied. Its weight is about nine and one-half ounces (av.) and it gives evidence of being rich in ferrous chloride (lawrencite).

The length of the mass, with the two pieces placed together as closely as possible, is 78^{mm}. Its greatest width is 33^{mm} and its greatest thickness 20^{mm}. It weighs 270 grams as a whole. The piece of which an engraving is herewith given, natural size, measures $20\times51\times55^{mm}$ and weighs 160 grams.

No other member of this "fall" has as yet been found, though the miners working in the neighborhood of its discovery have for several years been on the lookout for them in all the gravel workings.

Newark, N. J., March 30, 1900.

Art. XXXVII.—*Explorations of the "Albatross" in the Pacific;* by Alexander Agassiz.

IV.

[*Letter No. 4*, on the Cruise of the Albatross, dated Yokohama, Japan, March 5, 1900, to Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries, Washington, D. C., by Alexander Agassiz.]

After coaling and refitting we left Suva on the 19th of December, and arrived at Funafuti on the 23d, stopping on the way at Nurakita, the southernmost of the Ellice Islands. I was, of course, greatly interested in my visit of Funafuti, where a boring had been made under the direction of a committee of the Royal Society, in charge of Professor David, of Sydney, after the first attempt under Professor Sollas had failed. The second boring reached a depth of more than 1100 feet. This is not the place to discuss the bearing of the work done at Funafuti, as beyond the fact of the depth reached we have as yet no final statement by the committee of the interpretation put upon the detailed examination of the core obtained, and now in the hands of Professor Judd and his assistants. In addition to the above-named islands, we also examined Nukufetau, another of the Ellice Group.

After leaving Nukufetau we encountered nothing but bad weather, which put a stop to all our work until we arrived under the lee of Arorai, the southernmost of the Gilbert Islands. On our way from Tapateuea we steamed to Apamama and Maiana, which we examined, as well as Tarawa. We next examined Maraki, an atoll which is nearly closed with high beaches, having only two small boat passages leading through the narrow outer land-rims. Both Maraki and Taritari, the last island of the Gilberts which we examined, are remarkable for the development of an inner row of islands and sand-bars in certain parts of the lagoon parallel to the outer land-rim, a feature which also exists in many of the Marshall Islands atolls.

We reached Jaluit the 9th of January, and after a few days spent in coaling, we spent about three weeks in exploring the Marshall Islands, taking in turn the atolls of the Ralick Chain to the north of Jaluit: Ailinglab Lab, Namu, Kwajalong, and Rongelab; and then the atolls of the Ratack Chain, Likieb, Wotje, and Arhno. The atolls of the Marshall Group are noted for their great size and the comparatively small area of the outer land-rims, the land-rims of some of the atolls being reduced to a few insignificant islands and islets. In none of the atolls of the Ellice, Gilbert or Marshall Islands were we

able to observe the character of the underlying base which forms the foundations of the land areas of these groups. In this respect these groups are in striking contrast to the Paumotus, the Society Islands, the Cook Group, Niue, the Tongas, and the Fiji Islands, where the character of the underlying foundations of the land-rims is readily ascertained. But, on the other hand, these groups give us the means of studying the mode of formation of the land-rims in a most satisfactory manner, and nowhere have we been able to study as clearly the results of the various agencies at work in shaping the endless variations produced in the islands and islets of the different atolls by the incessant handling and rehandling of the material in place, or of the fresh material added from the disintegration of the sea or lagoon faces of the outer land, or of the corals on the outer and inner slopes. It has been very interesting to trace the ever-varying conditions which have resulted in producing so many variations in the appearance and structure of the islands and islets of the land-rims of the different groups.

The boring at Funafuti will show us the character and age of the rocks underlying the mass of recent material of which the land-rim, not only of that atoll, but probably also that of the other atolls of the group and of neighboring groups, is composed, though of course we can only judge by analogy of the probability of the character of the underlying base from that of the nearest islands of which it has been ascertained. When we come to a group like the Marshalls we have as our guide only the character of the base rock of the islands of the Carolines, which is volcanic, while Naru and Ocean Islands, to the west of the Gilberts and to the southwest of the Marshalls, indicate a base of ancient Tertiary limestone.

Owing to the continued stormy weather and the probability of not being able to land at these islands while the unfavorable conditions lasted, we did not attempt to visit them.

After leaving Suva we made a number of soundings from south of Nurakita toward the Marshall Group, which, in addition to those of the 'Penguin,' clearly show that the Ellice Islands are isolated peaks rising from considerable depths (from 1500 to over 2000 fathoms) and that the same is the case with the Gilbert Islands. We made about thirty soundings between the atolls of the Marshalls, which appear to show that they also rise as independent peaks or ridges, with steep slopes, from 2000 to 2500 fathoms, and that the so-called parallel chains of atolls of the Marshalls, the Ralick and Ratack, are really only the summits of isolated peaks rising but a few feet above the sea-level. The Marshall Islands, as well as the Ellice and Gilbert, seem to be somewhat higher than the Paumotus, but this difference is only apparent and is

due to the difference in the height of the tides, which is very small in the Paumotus, while in these groups it may be five and even six feet.

From Jaluit we visited among the Carolines, the islands and atolls of Kusaie, Pingelap, Ponapi, Andema, Losap, Namu, the Royalist Group, Truk and Namonuito, obtaining thus an excellent idea of the character of the high volcanic islands of the group from our examinations of Kusaie and of Ponapi, while the others represent the conditions of the low atolls, having probably a volcanic basis, but this was not observed at any of those we examined.

The reefs of the volcanic islands of the Carolines are similar in character to those of the Society Islands, though there are some features, such as the great width of the platforms of submarine erosion of Ponapi and of Kusaie, and the development of a border of mangrove islands at the base of the volcanic islands, which are not found in the Society Islands.

The Truk Archipelago was perhaps the most interesting of the island groups of the Carolines, and it is the only group of volcanic islands surrounded by an encircling reef which I have thus far seen in the Pacific which at first glance lends any support to the theory of the formation of such island-groups as Truk by subsidence. This group was not visited by either Darwin or Dana; and I can well imagine that an investigator seeing this group among the first coral reefs would readily describe the islands as the summits, nearly denuded, of a great island which had gradually sunk, But a closer examination will readily show, I think, that this group is not an exception to the general rule thus far obtaining in all the island groups of the Pacific I have visited during this trip; that we must look to submarine erosion and to a multitude of local mechanical causes for our explanation of the formation of atolls and of barrier and encircling reefs, and that, on the contrary, subsidence has played no part in bringing about existing conditions of the atolls of the South and Central Pacific.

Nowhere have we seen better exemplified than at Truk how important a part is played by the existence of a submarine platform in the growth of coral reefs. The encircling reef protects the many islands of the group against a too rapid erosion, so that they are edged by narrow fringing reefs, and nowhere do we find the wide platforms so essential to the formation of barrier reefs. The effect of the northeast trades blowing so constantly in one direction for the greater part of the year is of course very great; the disintegration and erosion of islands within its influence is incessant, and their action undoubtedly one of the essential factors in shaping the atolls of the different groups, not only according to the local posi-

tions of the individual islands, but also according to the geographical position of the groups. Thus far I do not think any observer has given sufficient weight to the importance of the action of the trades in modifying the islands within the limits of the trades, nor has anyone noticed that the coral reefs are all situated practically within the limits of the trades both north and south of the equator.

The soundings made going west from Jaluit to Namonuito indicate that there is no great plateau from which the Carolines rise, but that the various groups are, as is the case with the neighboring groups of the Marshalls and Gilberts, isolated peaks with steep slopes rising from a depth of over 2000 fathoms. The line we ran from the northern end of Namonuito to Guam developed the eastern extension of a deep trough running south of the Ladrones. The existence of this trough had been indicated by a sounding of 4475 fathoms to the southwest of Guam made by the Challenger. We obtained, about 100 miles southeast of Guam, a depth of 4813 fathoms, a depth surpassed only, if I am not in error, by three soundings made by the Penguin in the deep trough extending from Tonga to the Kermadecs.

I was very much surprised, in approaching Guam from the eastward, to find that the island was not wholly volcanic, but that the northern half consists of elevated coralliferous limestone. The vertical cliffs bordering the eastern face rise from a height of 100 to 250 or 300 feet at the northern extremity, and resemble in a way similar islands in the Paumotus (Makatea), Niue, Eua, Vavau and others in the Fijis which had made their cliffs a familiar feature in our explorations. In fact, outside of Viti Levu and Vanua Levu, this is the largest island known to me where we find a combination of volcanic rocks and of elevated coralliferous limestone. The massif forming the southern half of the island is volcanic, and the highest ridge, rising to about 1000 feet, runs parallel to the west coast, the longest slope being toward the east.

This volcanic mass has burst through the limestone near Agaña, and the outer western extension of the coralliferous limestone exists only in the shape of a few spurs running out from the volcanic mass, the largest of which are those forming the port of San Luis d'Apra. These spurs are separated by lower ridges of volcanic rocks extending to the sea from the main central mass. To the north of Agaña the limestone forms an immense irregular mesa, cut by deep crevasses, full of pot-holes and sinks, rising gradually westward to a height of 350 or 400 feet. Near the northern extremity of the island a volcanic mass, Mt. Santa Rosa, has burst through the limestone and rises about 150 feet above the general level of that part of

the island. The shore stratification of the bluffs is much distorted in the vicinity of that volcanic outburst.

We left Guam in time to reach Rota by day, and found that this island is a mass of elevated coralliferous limestone, the highest cliffs of which reach a height of 800 feet. Perhaps in none of the elevated islands have we been able to observe the terraces of submarine elevation as well as at Rota, especially in the small knob at the southwest point of the peninsula separating Sosanlagh and Sosanjaya bays, which itself is also terraced; no less than seven distinct terraces could be traced. There was no sign of any volcanic outburst except at the northwest point of the island, where both the character of the slope and of the vegetation would seem to indicate a volcanic structure.

It is quite probable that others of the Ladrones, like Saipan, and the islands to the south, are composed in part at least of elevated limestone, judging from the hydrographic charts and the sketches which accompany them. On many of the northern Ladrones there are active volcanoes, so that it is very possible that the volcanic outbursts which have pushed through the limestones, or have elevated parts of the islands of the group, are of comparatively recent date.

During the last part of our cruise, from Suva to Guam, the unfavorable weather greatly interfered with our deep-sea and pelagic work; in fact with the exception of the soundings made to develop as far as practicable the depths in the regions of the various coral-reef groups we visited, we abandoned all idea of carrying out the deep-sea and pelagic work planned for the district between the Gilbert and Marshall and Caroline groups. To our great disappointment hardly any marine work could be accomplished, and our investigations were limited almost entirely to the study of the coral reefs of the regions passed through.

After Mr. Townsend's departure, Dr. Moore continued to collect the birds of the islands where we anchored, and they have brought together a fairly typical collection of the avifauna of the South Sea Islands. Dr. Pryor collected the characteristic plants, and Dr. Mayer the insects and reptiles in addition to such pelagic work as could be done in port. Both Dr. Woodworth and Dr. Mayer took a large number of photographs, and we must have at least 900 views illustrating the coral reefs of the Pacific. Dr. Woodworth also collected incidentally such ethnological material as could readily be obtained during our short stay at different places.

We were everywhere received with the greatest cordiality and courtesy: by the Governor of the Paumotus, the King of Tonga, Sir George O'Brien (the High Commissioner of the Western Pacific at Suva), Mr. E. Brandeis (the Landes-Haupt-

mann in charge of the Marshall Islands at Jaluit), and the Governor of the Carolines, and the Japanese authorities. The State Department at Washington having kindly asked through the French, English, German and Japanese Embassies at Washington for the kind offices of the representatives of these nations in Oceania to the Albatross while in their respective precincts, thanks to these credentials nothing could exceed the interest shown everywhere in the success of our expedition.

I must also thank Capt. Moser and the officers of the Albatross for the untiring interest shown by them during the whole time of our expedition in the work of the ship, which was so foreign to the usual duties of a naval officer.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Viscosity of Argon as affected by Temperature.*—Lord Rayleigh has carried on a series of experiments on the above subject, special interest being connected with it since argon as regards specific heat behaves as if monatomic. The author says :

"When we remember that the principal gases, such as oxygen, hydrogen, and nitrogen, are regarded as diatomic, we may be inclined to attribute the want of simplicity in the law connecting viscosity and temperature to the complication introduced by the want of symmetry in the molecules and consequent diversities of presentation in an encounter. It was with this idea that I thought it would be interesting to examine the influence of temperature upon the viscosity of argon, which in the matter of specific heat behaves as if composed of single atoms. From the fact that no appreciable part of the total energy is rotatory, we may infer that the forces called into play during an encounter are of a symmetrical character. It seemed, therefore, more likely that a simple relation between viscosity and temperature would obtain in the case of argon than in the case of the "diatomic" gases.

The best experimental arrangement for examining this question is probably that of Holman,* in which the same constant stream of gas passes in succession through two capillaries at different temperatures, the pressures being determined before the first and after the second passage, as well as between the two. But to a gas like argon, available in small quantities only, the application of this method is difficult. And it seemed unnecessary to insist upon the use of constant pressures, seeing that it was not proposed to investigate experimentally the dependence of transpiration upon pressure." . . .

"Although different gases have been employed in the present experiments, there has been no attempt to compare their viscosities, and indeed such a comparison would be difficult to carry out by this method. The question has been, how is the viscosity of a given gas affected by a change of temperature ? In one set of experiments the capillary is at the temperature of the room ; in a closely following set the capillary is bathed in saturated steam at a temperature that can be calculated from the height of the barometer."

In the experiments the times of transpiration were found to be 104·67 seconds at the temperature of the room (15°) and 167·58 at 100°·27. The relation between the times of transpiration (t) and the absolute temperatures (θ) is given by the equation $\frac{t'}{t} = \left(\frac{\theta'}{\theta}\right)^x$, whence is obtained the value $x = 1{\cdot}812$. As the

* Phil. Mag., vol. iii, p. 81, 1877.

integral part of x relates merely to the expansion of the gas by temperature, the relation between the viscosities (μ) and temperatures (θ) is given by the formula $\frac{\mu'}{\mu} = \left(\frac{\theta'}{\theta}\right)^n$, whence $n = 0{\cdot}812$ or, as finally corrected, 0·822. The author concludes:

"The following table embodies the results obtained in a somewhat extended series of observations. The numbers given are the values of n, corrected for the expansion of the glass.

Air (dry)	0·754
Oxygen	0·782
Hydrogen	0·681
Argon (impure)	0·801
Argon (best)	0·815

In the last trials, the argon was probably within 1 or 2 per cent of absolute purity. The nitrogen lines could no longer be seen, and scarcely any further contraction could be effected on sparking with oxygen or hydrogen.

It will be seen that the temperature-change of viscosity in argon does not differ very greatly from the corresponding change in air and oxygen. At any rate the simpler conditions under which we may suppose the collisions to occur, do not lead to values of n such as 0·5, or 1·0, discussed by theoretical writers."—*Proc. Roy. Soc.*, lxvi, 68.

2. *Behavior of Becquerel and Röntgen rays in a magnetic field;* by R. J. Strutt.—Referring to the fact that it has been proved that Becquerel rays are deflected in a magnetic field, the author remarks that this result is of great interest on account of the light which it throws on the nature of the rays. He says:

"Up to the present, the evidence has tended to show that the Becquerel rays were of the same nature as the Röntgen rays, both being capable of penetrating thin metal sheets, of affecting a photographic plate, and of producing ionization in the surrounding air. Neither could be refracted or reflected; and so far as has yet appeared, neither could be polarized.

These facts seemed to form a fairly strong body of evidence that the two kinds of radiation were essentially similar. But the announcement of the magnetic deflectibility of the Becquerel rays seems to throw doubt on this conclusion. The Röntgen rays, so far as is known, are quite unaffected by magnetic force. Under these circumstances it seemed worth while to make a new attempt to discover such an effect on the Röntgen rays. This attempt I have carried out. It will be best to say at once that the result is negative.

A focus tube was employed as the source of radiation. It was placed at a distance of about 35^{cm} from a powerful electromagnet, and in such a position that the cathode rays in the tube were parallel to the magnetic force due to the magnet. The line joining the oblique anti-cathode to the center of the magnetic field lay in the plane of the anti-cathode.

A short distance in front of the magnet a wire was placed at right angles to the direction of the rays, and in the plane of the anti-cathode. It was thus at an angle of about 50° to the magnetic force—the same angle as that between the axis of the cathode stream and the anti-cathode. This wire was used to cast a shadow on a photographic plate placed at a distance of 65^{cm} on the other side of the magnet.

An exposure was first made with the magnetic force in one direction. The exposure was then stopped, the field reversed, and another exposure given, of course without shifting the plate. If then the rays had been appreciably deflected, the photograph should have shown two shadows, either overlapping, or altogether separated.

The rays casting the shadow were those emitted at a grazing angle from the anti-cathode. The reason for using these very oblique rays was that owing to the foreshortening of the anti-cathode, the source was virtually narrower than it would have been, had rays been used which left the anti-cathode at a greater angle. Thus sharper shadows were obtained, and a smaller magnetic deflection could have been detected.

The tube was arranged with its cathode stream parallel to the magnetic field, so as to avoid any shifting of the source of radiation when the magnet was reversed, owing to an effect of the magnet on the original cathode beam. Such a shifting would have given rise to a spurious effect. The only objection to this was that the shadow-casting wire had to be obliquely placed so as to be in the plane of the anti-cathode. Thus some sensitiveness was lost."

A discussion of the results obtained shows that a field of a strength 3270 C. G. S. units does not produce a curvature of radius less than $19{,}800^{cm}$, hence the field required to produce a curvature of 1^{cm} cannot be less than $6{\cdot}5 \times 10^7$.

An estimate of the amount of magnetic reflection of the Becquerel rays was also made; the result showed a radius of curvature of 3^{cm} in a field whose strength was 1680 C. G. S. units. Hence the field required to produce a curvature of 1^{cm} is about 5×10^3. Using also the results of J. J. Thomson, who shows that a beam of cathode rays was bent to a radius of curvature of 9^{cm} in a field of 35 units, it is calculated that a field of 315 would have been required to bend it to a radius of 1^{cm}. Hence the following results brought together for comparison :

"The field which would be required to produce a curvature of 1^{cm} radius would be

For cathode rays	3×10^2
" Becquerel rays	5×10^3
" Röntgen rays not less than ...	6×10^7

If the Röntgen rays are magnetically deflected at all, it is by an amount less than a ten-thousandth part of that observed in the case of the Becquerel rays.

The magnetic deflectibility of the Becquerel rays cannot but be considered to be a most characteristic property. And the above result appears to make it tolerably certain that the Röntgen rays do not possess this property. It is to be concluded, therefore, that the Becquerel rays are, after all, essentially different in character from the Röntgen rays."—*Proc. Roy. Soc.*, lxvi, 75.

3. *Becquerel Rays. Confirmation of the Material Theory of the deviable Rays of Radium.*—Radium has again occupied the post of honor during the last fortnight. After the discoveries of which we have recently written, a quiet time was to be expected; such, however, has not been the case, and far from diminishing in importance, the facts made known during these last few weeks surpass in novelty and interest all those of which the discovery has already excited such enthusiasm.

For some time we have been working in the dark, and were vainly endeavouring to find the point whence light would come. We already knew that the emission of radium did not agree with our ideas on ether waves; but the facts already known did not yet warrant us in believing that it was of a material nature. A decisive experiment of this kind, as we shall see immediately, has just been made by M. Curie; however, to properly understand and appreciate it, it is necessary to consider the question a little further back.

In a paper recently presented to the Academy, M. Becquerel has pointed out several remarkable facts with regard to the propagation of the emission of radium. The active substance was contained in a little recess, hollowed in a lead slab, placed directly on the photographic plate, and the whole was placed in a uniform magnetic field parallel to the plate. Under these conditions the impression due to the rays emitted from below upwards, and bent back on to the photographic plate by the action of the magnetic field, is limited on the side of its source by an elliptical arc, in the interior of which no photographic action can be observed, while such action can be seen diffused gradually towards the parts farthest distant from the source. The rays have thus described the arcs, of which the shortest are situated in the plane perpendicular to the direction of the field, while the oblique arcs have rays of much greater length.

The aspect alone of the photographic plate shows that the emission is complex, since the same field acts in a different manner on the various rays emanating from the source. But this complexity becomes still more evident if we interpose screens in the trajectory of the rays. Under these conditions the impression nearest to the source is suppressed, the line of light recedes, and gets farther from the source the more the substance is absorbent. We thus see that the strongly curved rays are absorbed more than the others, without any other apparent selection, no matter what the screens are made of.

Now let us examine this characteristic from the point of the materialist theory of the rays, and let us suppose that the particles emitted by the radium have different speeds.

We know that for a same quotient of mass by the charge, the product of the field by the radius of curvature is proportional to the speed.* Thus the particles which strike the plate the farthest from the source will be those possessing the greatest speed, and it is natural that they should also be the most penetrating.

This is a simple idea from which a presumption may result, but not a certainty. In fact other hypotheses could explain the same coincidence which can only be considered as an accessory proof. But the experiment of M. Curie gives us a proof of another order. He has placed beyond doubt the fact that *the emission of radium charges bodies which receive it negatively, while the radium itself is charged positively.*

This fact is of such importance, it throws such sudden light on the whole question, that the eminent physicists to whom we owe these marvelous discoveries would naturally wish to put it in evidence, and we believe they would have succeeded sooner had it not been for the extraordinary difficulties offered by the experiment. We do not propose to give it in detail, or to diminish the interest of the publication *in extenso* which belongs to M. and Mdme. Curie. We will only say that the extreme minuteness of the effects to be measured necessitated the most delicate apparatus, and that the method with piezo-electric quartz, of which M. and Mdme. Curie have made such constant and skilful use, alone could lead to positive results. But this is not all. The already known action of the new radiations was the principal obstacle to the success of the experiment. Radium placed at the mouth of a Faraday cylinder, while sending its own charged particles into the interior, created by that action a permanent conductor along their path, and provoked the immediate dissipation of the whole of the charges carried. It was therefore necessary to abandon this simple method, and to have recourse to a series of artifices, of which the most important consisted of enclosing the receiver in a double envelope, the first or outer one consisting of a metallic sheet connected to earth, while the second was isolated. A part of this double envelope was formed of thin leaves, permitting the radiation to reach the receiver.

In a second experiment, the radium itself was enclosed in the double envelope and discharged its negative charge to the exterior without compensation.

Only one interpretation seems still possible, at least for a portion of the emission of radium; *this emission is composed of material particles carrying negative charges.*

We might, at first sight, ask if the non-deviable rays are not a particular form of deviable rays. This does not seem to be the case, for the absorption they undergo would rather send them beyond the most deviable rays which have been met with. They are either of another kind, or they have been deprived of their charge of electricity. This latter idea is still admissible, and the

* $\frac{m}{e}V = H\rho$, an equation established to explain the curvature of cathodic rays.

singular manner in which these rays behave with regard to absorption, as we have pointed out in a recent article, would seem to confirm the idea.

Will this collection of well-grounded ideas remove the last difficulties? To affirm this would be to proceed too quickly, since the cause of the bombardment is not yet apparent to us. In any case the first objection which comes to our minds, that of a necessary loss of mass of the radium, will not stand examination, for, as has been shown by M. Curie, the charges carried off are so feeble, that if we admit the same proportions as with cathodic rays, some millions of years would be required to remove one m. grm. in the case of the most intense radiation that has yet been observed.

What can, however, be said with certainty, is that the new discoveries singularly limit the field for hypotheses, and by fixing the direction for research permit us to forsee a generalisation of great magnitude which will be of great attraction in the study of certain properties of matter to which in the last few years a large body of scientific men have turned.—*Revue Générale des Sciences,* No. 5, March 15, 1900.—*Chem. News*, lxxxi, 145.

4. *The Echelon Spectroscope and the Zeeman effect.*—A paper by Lord Blythswood and Dr. E. W. Marchant, in the April number of the Philosophical Magazine, gives an interesting account of investigations made with the echelon diffraction-grating invented by Professor A. A. Michelson (this Journal, v, 215, 1898). It shows how admirably it is adapted, as early pointed out by the inventor, for the study of certain phenomena, e. g. the Zeeman effect. The grating used by the present authors was by Hilger and consisted of fifteen plates, each about $7{\cdot}5^{mm}$ in thickness, made of light flint glass and set, as finally arranged, so as to make steps $\cdot 5^{mm}$ wide. This was combined with the telescope and collimator of a large goniometer, the telescopes having object-glasses of twenty-eight inch focus and two inch aperture. A small solar telescope was employed to obtain the necessary preliminary dispersion. The methods of adjusting the instrument are described in detail, and also the values deduced for the constant of the grating, which depends for its value upon the wave-length of light and the refractive index of the glass employed. When this constant is known, the difference in wave-length between two lines seen in the echelon may be determined if their dispersion relative to the distance between two successive orders is known. This constant is independent of the width of the steps, so that it is immaterial how they are put together, the only condition being that the instrument shall not be much tilted; or, in other words, that the light shall pass through in a direction nearly normal to the plates. A large magnet was employed, giving a field up to 40,000 C. G. S. units. The effects especially observed were those for the blue (4358) and green (5460) lines of the mercury spectrum. Both of these could be photographed, the former requiring an exposure of from ten to

twenty minutes and the latter of about two hours. The two yellow lines were also examined, but no good photographs obtained from them. The special results obtained in each case are given in detail with a series of photographs, both for the single- and double-order condition. Observations were made both across and along the lines of force. With respect to the *blue line* (4358), it was found, for example, that under a weak magnetic field the line appears as a triplet; as the strength of the field increases the lower component splits into a doublet and the line into a quartet. As seen in the single-order photograph, the line finally becomes a sextet, the field having a strength of 23,400 units. The *green line* (5460) in a weak field (6000 units) splits into a triplet; with increase of strength the inner component splits into a triplet, while each of the outer lines splits into a doublet, the resultant being a septet; the outer lines, however, are really due to three orders.

The authors close their paper with the following remarks regarding the working of the instrument:

"In order, therefore, to make this valuable instrument more serviceable for this class of work, attention should be directed to the increase of the constant without too much diminution of the resolving power. As suggested by Michelson, this might be done by surrounding the instrument, say, with water. This, however, would reduce the resolving power to only one-third of its original value. A better suggestion is that of using thinner plates for the instrument and more of them. The plates might with advantage be made, say 4^{mm} thick with, say, thirty plates and $\cdot 5^{mm}$ steps, or even $\cdot 25^{mm}$ steps. This would, we believe, make a more useful instrument for this work than one consisting of thirty 8^{mm} plates, though theoretically the resolving-power is only half what it would be in the latter case. There is, of course, no doubt that this instrument forms a most valuable addition to the apparatus available for work on the Zeeman effect."

5. *Effects of ultra-violet light on gaseous bodies.*—Much attention has been paid to the effect of the X-rays on air and gases. Under the action of the cathode and X-rays, air becomes a conductor, its oxygen is partially converted into ozone and nuclei of steam condensation are formed in it. P. Lenard calls attention to the fact that ultra-violet light exerts similar effects. In his experiments on steam condensation by means of ultra-violet light, it was found that the light from aluminum spark terminals was far more operative than that from other metals. The following is the list of metals and distances at which the working of their ultra-violet radiations began to be noticeable:

Al	Cd	Sn	Pb	Zn	Mg
50	36	27	20	18	12 cm.

The region of the spectrum where the effects of ultra-violet light on gaseous bodies begins is that where the measures of dispersion end. The rays concerned in these peculiar effects have

been identified only by Schumann—and by him only in a vacuum. Lenard calls attention to some experiments made in the Alps by him in 1889, which showed the effect of sunlight in dissipating electrical charges. Since the spectrum of the sun's chromosphere and the protuberances show the presence of hydrogen, and Schumann's results show that this gas is especially rich in the short waves which are absorbed by the earth's atmosphere, it is reasonable to attribute the results obtained by Lenard in the Alps to the ultra-violet rays, which are absorbed at lower altitudes.—*Ann. der Physik.*, No. 3, 1900, pp. 486–507. J. T.

6. *Dielectric Constant of Water and Hydrogen peroxide.*—H. T. Calvert has determined the dielectric constant of hydrogen superoxide by means of electrical waves according to the method of Drude. The wave length that was employed had $\lambda=75^{cm}$ and only a trace of electrical absorption was shown. The constant obtained for the hydrogen peroxide — H_2O_2 — was 92·8, while that of water, H_2O at 18°, was 81. The hydrogen peroxide has therefore a much greater dielectric constant than pure water.—*Ann. der Physik.*, No. 3, 1900, pp. 483–485. J. T.

7. *Quincke's Rotations in an Electric Field.*—This investigator showed that a sphere of paraffine-ebonite or sulphur is set in rotation when charged and suspended in an electric field. This rotation is due to the repulsion of the electricity residing on the surface of the spheres by the electricity on the neighboring electrodes between which the revolving bodies are suspended. L. Graetz shows that the conductibility of poor conductors and its changes under varying conditions can be determined by Quincke's phenomenon. The effect of the X-rays also in changing the conductibility of such substances and of gases can be studied by the same means.—*Ann. der Physik.*, No. 3, 1900, pp. 530–541. J. T.

II. Geology and Natural History.

1. *The Slate Belt of Eastern New York and Western Vermont;* by T. Nelson Dale. (Extract from 19th Annual Report of U. S. Geol. Survey, pp. 153–307.)—Few regions of equal extent offer such difficult problems in stratigraphy and structural geology as the two counties along the New York–Vermont boundary described in this report. Walcott has discussed in several papers the paleontologic teachings of the area, and the economic importance of this region, which produces one quarter of the roofing slate used in the United States, has long been known. Prof. Dale has surveyed the field anew and has made a combined economic and scientific study of the complicated area with special attention to the intricate structural relations existing there. Ten sections were worked out across the slates and adjoining schists at important and favorable points and the general structural features found to be as follows: "The strata of the schist mass on the east, closely plicated and cleft with easterly dipping slip cleavage, lie in

broad undulations, but are crowded over at the west into a somewhat sharp anticline." In the Cambrian slate mass there are close folds more or less overturned to the west with easterly dipping slaty cleavage obscuring the bedding. "The folds are so close and the cleavage is so pronounced that the cores of adjoining synclines and anticlines are brought very near together or the anticlinal portions of several folds do not appear. Series of various folds form compound anticlines and these minor Cambrian anticlinoria alternate with Ordovician synclinoria conformably overlying Cambrian ones." The details of structure along these sections—bedding, cleavage, grain, etc. are fully discussed and illustrated by numerous photographs and diagrams.

Much attention has been given in this paper to the chemical and mineralogical composition of the slates. Complete analyses have been made of seven varieties and the mineralogical composition of the various types has been determined by careful examination of over 200 thin sections. In addition to the microscopic descriptions, five colored lithographic representations of microscopic sections are given of each variety of commercial importance. These illustrate clearly the differences in texture and composition which underlie differences in quality and color.

Under the head of Scientific Geology (pp. 278–300) Prof. Dale deals with the more purely scientific problems connected with slates in general and those of the New York–Vermont region in particular. He first reviews the present state of science on the chemical and physical constitution and origin of slates. This critical discussion taken together with the bibliography (pp. 166-174) is especially valuable for students in that it brings together in an American publication a synopsis of all that is known about "slate." Several pages are next devoted to the complex question of the relations between the Lower Cambrian and the Lower Ordovician in this region. Indications of slight unconformity between these horizons are noted and the probability of local diversity of contemporaneous sedimentation is explained. The geological history of the slate belt is the last subject of a theoretical nature treated. In brief the history is as follows: A land surface chiefly of granites and gneisses was covered by the sea in which were deposited Lower Cambrian sediments which show by their character great variations in conditions of deposition. For some reason no Middle and Upper Cambrian deposits were laid down, but grits, shales and slates of the Ordovician follow the Lower Cambrian directly. At the close of the Ordovician, the accumulated sediments, both Cambrian and Ordovician, gradually emerged in folds more intensely plicated toward the east. The increasing pressure produced metamorphism and percolating alkaline waters deposited silica in openings formed by the folding. These movements produced the slates. At some later time another movement occurred resulting in diagonal joints, quartz veins, shear zones and other secondary structures. Some of the fractures were so deep as to occasion

dikes—22 of which are mapped. The remaining geological history is concerned with the events which transpired in the Glacial, Champlain and Recent periods. H. E. G.

2. *A Contribution to the Geology of the Northern Black Hills;* by JOHN DUER IRVING. Annals New York Academy of Sciences, Vol. xii, No. 9, pp. 187–340, Pls. v–xvi, figs. 5–20.—This paper is for the most part a detailed petrographical study of an area just west of Deadwood, So. Dakota, which is important because of its interesting rock types and intrusions, and also as the home of an increasing mining industry. The first few pages of the report are devoted by Dr. Irving to a description of the Algonkian, Cambro-Silurian and Carboniferous strata, after which the eruptives which occur here in great variety are discussed. The position of the intrusions indicates that the Black Hills were twice subjected to prolonged igneous disturbances; once previous to the metamorphism of the Algonkian when the intrusions were basic (amphibolites); and again during Post-Cretaceous times after the Paleozoic and Mesozoic sediments had been deposited. These later intrusives are alkaline and have no genetic relationship with the amphibolites. In considering the form assumed by the intrusions, the author differs somewhat from Newton, Russell, and other workers in this region. He concludes 'that the influence of the rocks into which the magmas are intruded has been the determining factor of the form assumed by the intrusion' (p. 244).

Petrographical examination of the rocks shows eight families, as follows: grorudite, phonolite, rhyolite, andesite, dacite, diorite, lamprophyre, amphibolites. Phonolite occurs most abundantly and is described at considerable length.

The ore bodies of the region are found in three geological ages—Algonkian, Cambrian and Carboniferous. The Algonkian ores occur as impregnated zones in the metamorphosed slates and schists, like the Homestake mine at Lead City. The Cambrian areas which for the last few years have yielded the greatest output of all the Black Hills Mines are replacements of impure limestones by siliceous solutions bearing gold. The Carboniferous ores which have not as yet been fully exploited are silicified brecciated limestone, much like the Cambrian deposits. Numerous diagrams, sections and photographs increase the usefulness of the work. H. E. G.

3. *Description of a New Genus and Twenty New Species of Fossil Cycadean Trunks from the Jurassic of Wyoming;* by LESTER F. WARD. Proceedings of the Washington Academy of Sciences, vol. i, pp. 253-300 (Pl. XIV–XXI), Feb. 14, 1900.—In this contribution Professor Ward adds another important chapter to our knowledge of the cycadean vegetation of the North American Mesozoic.

The determination of the new genus and species is the result of a study of 85 specimens from Carbon County, Wyoming. Of the types, two, *Cycadella Beecheriana* and *Cycadella Reedii*

belong to the Yale collection. The remaining eighteen types as enumerated below are the property of the University of Wyoming at Laramie.

The discovery of these cycads by W. H. Reed and their Jurassic age was first announced in this Journal by Prof. O. C. Marsh in a note on "Cycad Horizons in the Rocky Mountains," vol. v, p. 197, Aug., 1898.

Professor Wilbur C. Knight is also quoted as follows: "There is no question as to the horizon of these Cycads. It is in the Jurassic fresh-water beds and near the bottom.

* * * * * * *

A section through the locality of the cycad beds will be about as follows:

Triassic red sandstone, 1000 feet.

Lower Jurassic (marine), 200 feet.

Upper Jurassic (fresh-water), 225 feet.

Dakota Conglomerate, from 50 to 200 feet."

Further, Professor Ward as the result of a personal visit to the new locality confirms the previous observations on its stratigraphical position as follows: "The section of the Freeze-Out Hills immediately to the east of the cycad bed and including the ledges formed by the stratum in which they occur was carefully measured. It is a characteristic section since it extends from the Red Beds at the bottom of the valley to the Cretaceous which caps the hill and is supposed to represent the Dakota Group, although such an examination of it as I was able to make led me to suspect that it is the equivalent of the Lower Cretaceous of the Black Hills, possibly extending, in some places, to the true Dakota Group of Meek and Hayden.

The following is the section:

Lower Cretaceous capping the hill	50 feet.
Base of Cretaceous to top of cycad bed	100 "
Thickness of cycad bed	10 "
Bottom of cycad bed to top of Marine Jurassic	80 "
Thickness of Marine Jurassic to bottom of valley on Red Beds	115 "
Total exposure	355 feet."

The name *Cycadella* is a very appropriate one for this new series of pygmaic species,—on the average scarcely a tenth the size of the trunks from the Black Hills. The generic distiunction is based mainly on the remarkable development of a secondary ramentaceous covering of the trunks, the general structure, course of the leaf bundles and lateral position of the axes of fructification being otherwise that seen in the genus *Cycadeoidea*.

Professor Ward says: "The most marked feature that struck me on first casual inspection of these trunks, aside from their relatively small size, light color, and soft calcareous [silicified] structure, was the frequency of a sort of smooth, to the naked

eye, structureless, dull, uniform, covering that invests their outer surfaces and cuts off the view of the normal organs of the armor. A closer examination revealed the fact that this was not an occasional condition but the normal state of these cycads, and that the cases in which this outer coating is wanting represent the abnormal state. It further became clear that there really are no cases in which it is naturally absent, and that its absence is always due to some external influence acting upon the surface which has removed it. * * * *

"The special susceptibility to petrifaction on the part of the ramentum explains the presence of the external covering of the Wyoming Jurassic cycads, since it seems actually to consist in a mass of these ramentaceous hairs, which in some way developed so luxuriantly upon the sides of the petioles, as to push out beyond the surface, and roll over the spaces formerly occupied by the leaves and fruits. It seems necessary to assume that this occurred long after the fall of the leaves, and, indeed this latter doubtless took place much as it does in living cycads, the leaves always forming a crown to the trunk and falling away as the trunk elongates, leaving only their persistent bases to form a false bark. These are not wholly dead, but manifest vegetative activity, and doubtless have some physiological function."

From these facts, supported by sections and polished surfaces, it is decided, that "*Cycadella* developed an exuberant growth of fine scales or hairs from the bases of its old petioles below the apex, which formed a woolly or mossy covering of considerable thickness, sufficient when tightly appressed to the trunk and petrified, there to form a layer 5–15^{mm} thick all over the fossil trunks."

Whoever has seen these trunks will certainly grant from the briefest observation that their development of ramentum was very profuse; and must have given the trunks below the crown of leaves the appearance seen in certain Cacti. Is it not quite possible that they grew in dry, cold, or semi-arid situations? This would account at least in part for their small size.

The present new series of cycadaceous plants greatly enhances the interest and value of the recent discovery and investigation of the remains of the extensive cycadean vegetation occurring in strata of the Black Hills rim regarded as lowermost *Cretaceous* by some and upper *Jurassic* by others.

The assigned species of North American cycadean trunks now numbers 52, referred to two genera as follows:

Upper Jurassic (?) of the Black Hills (Dakota and Wyoming); *Cycadeoidea dacotensis* Macbride, *colossalis*, *Wellsii*, *minnekahtensis*, *pulcherrima*, *cicatricula*, *turrita*, *Macbridei*, *Marshiana*, *furcata*, *Colei*, *Paynei*, *aspera*, *insolita*, *occidentalis*, *Jenneyana*, *ingens*, *formosa*, *Stilwelli*, *excelsa*, *nana*, and *Wielandi* (last 20 species Ward).

Upper Jurassic, central Wyoming,—*Cycadella Beecheriana*, *Reedii*, *Wyomingensis*, *Knowltoniana*, *compressa*, *Jurassica*, *nodosa*, *cirrata*, *exogena*, *ramentosa*, *ferruginea*, *contracta*, *gravis*, *verrucosa*, *jejuna*, *concinna*, *crepidaria*, *gelida*, *carbonensis and Knightii* (all Ward's species).

Potomac formation of Maryland (Upper Jurassic?).—*Cycadeoidea Marylandica* Fontaine, *Tysoniana, Fontaineana, McGeeana, Uhleri, Bibbinsi,* and *Goucheriana* (last 6 species Ward).
Trinity Beds (Comanche Series), Cheyenne Rock, Belvidere, Southern Kansas,—*Cycadeoidea munita* Cragin.
Pre (?) *Laramie* near Golden, Colorado,—*Cycadeoidea mirabilis* Lesquereux.
Upper Trias, North Carolina, locality lost,—*Cycadeoidea Emmonsi* Fontaine.
Trias of Prince Edward's Isle,—*Cycadeoidea abiquidensis* Dawson.

About 35 species of cycadean trunks, probably all belonging to the *Cycadeoidean* group, have been described from European localities, chiefly in strata of Upper Jurassic or questionably Lower Cretaceous age. Recent study of the microscopic features of the American forms made by the reviewer, and still continued, have shown their close parallelism to European forms.

The determination of this highly developed, extensive, and probably synchronous development of cycadean vegetation on both continents in the middle Mesozoic forms one of the most interesting additions to Palæo-botanical knowledge made in recent years. G. R. W.

4. *Geologic Atlas of the United States. Telluride Folio, Colorado. Areal Geology;* by WHITMAN CROSS assisted by Messrs. GANE, LORD and SPENCER. *Topography,* by FRANK TWEEDY.—The area described in this folio, which has recently become so well known from its valuable gold and silver mines, is situated in the "San Juan" region. The chief features of its geology are the Jura-Trias, Cretaceous strata with intrusions of igneous rocks in the form of stocks and laccoliths and the great outflows of rhyolite and piled up masses of rhyolitic tuffs and breccias.

We note a change from the former atlas sheets in that there are some 17 to 18 pages of text, instead of the usual two or three. With the large page this gives quite a full treatment of the geology of the district, equalling perhaps 125 to 150 pages of an ordinary octavo volume. In addition there are three half-tone plates of beautiful photographs giving eighteen views illustrating thoroughly the topographic features and broader geologic characters of the district. We trust that this advance in the scope of the atlas sheets will be a permanent one, especially in the increase of the descriptive matter in the text, since it will greatly increase the value of the work as a whole and particularly for local use.

In addition to the geology by Cross, there is a valuable chapter on the ore deposits by C. W. Purington, treating of the fissures, veins, etc. L. V. P.

5. *The Freshwater Tertiary Formations of the Rocky Mountain Region;* by W. M. DAVIS. Proceedings of the American Academy of Science, Vol. xxxv, No. 17, March, 1900.—The lacustrine origin of the freshwater Tertiary deposits of our western states was asserted by nearly all of the early workers on the geological surveys. Hayden, King, Powell, and Dutton describe the conditions and character of the depositions at some length, and their conclusions that they are lake sediments are supported

by the paleontological studies of Newberry, Cope and Marsh. Most of the later workers in the Rocky Mountain and Plains region consider the origin of the formations as settled, or give additional evidence to show the lacustrine origin of some smaller areas (e. g. Arapahoe and Denver Formations of Colorado). Naturally, too, the text books most widely used both in America and Europe assert unqualifiedly the existence of extensive lakes in the Rocky Mountain region during Tertiary time.

To the unquestioned acceptance of this time-honored interpretation, Professor Davis objects, and from a comparison with the fluviatile plains of the Po and of northern India, as well as from theoretical considerations, he has been led to recognize the possible non-lacustrine origin of the western Tertiary deposits. This possible explanation seems to be very closely related in the author's mind to the probable explanation, as some sentences show; e. g. "as far as the published descriptions of these deposits afford evidence of their detailed structure, it appears to me probable that streams and rivers have had more than lakes or winds to do with their formation, and hence that 'fluviatile' might often to advantage replace 'lacustrine' in describing them" (p. 360). As an aid in distinguishing the different classes of deposits, some pages are devoted to a useful discussion of the characteristics of lacustrine, fluviatile and æolian sediments.

The object of this paper, as announced by the author, "is to promote consideration, rather than to announce conclusions," and it is more than probable that the object will be attained, and an interesting and fruitful discussion called out, for geologists are not likely to abandon the lake hypothesis and the numerous geological and paleontological conclusions based upon it without most careful consideration. H. E. G.

6. *Text-Book of Paleontology by Karl A. von Zittel*, translated and edited by Chas. R. Eastman. Vol. I, pp. 1–706, with 1476 wood cuts. New York, 1900 (The Macmillan Co.).—With the publication of the second part, beginning with page 353, the first volume of this important work is completed. It includes the chapters on the Protozoa, Cœlenterata, Echinodermata, Vermes, Molluscoidea, Mollusca and Arthropoda. Notice of the first part was published in these pages when it first appeared (see vol. ii, p. 394). A characteristic feature of the translation is the free revision of the chapters by American specialists. The Pelecypoda is thoroughly revised by Dr. Dall. In the present classification the primary ordinal groups are Prionodesmacea, Anomalodesmacea, Teleodesmacea. The hinge-teeth furnish the more important characters for the secondary subdivision of the ordinal groups. The Gastropoda, revised by Professor Pilsbry, retain substantially the classification of the German edition. The sub-class Tetrabranchiata of the Cephalopoda has received a complete revision at the hands of Professor Hyatt; the arrangement as well as the definition of the groups has been much changed; very few of the older

ordinal or family names appear; the generic names and the figures are, however, substantially the same as in the original edition. A note on page 592 informs the reader that "the classification and diagnoses are condensed from an exhaustive monograph on fossil cephalopods at present still in MS." Prof. A. E. Verrill contributes several valuable notes regarding structure of the animal.

The chapter on Dibranchiata is little altered in the translation.

The chapter on Trilobita is not a translation, but an article prepared for the volume by Professor Beecher. It presents his own classification, which is based chiefly on ontogeny and the modification of the free-cheeks; a character which under the term *facial suture* plays so conspicuous a part in the earlier classification of Trilobites.

The section on Ostracoda is abridged from a fuller treatment of the group prepared by Mr. E. O. Ulrich; and Dr. John M. Clarke contributes the chapters on Phyllopoda, Cirripedia and Phyllocarida, also adding some new figures to their sections and to the chapter on Merostomata.

Professor J. S. Kingsley revised the other orders of Malacostraca and all the chapters on Arthropoda have received his expert criticism.

The chapter on Insects is revised by Professor S. H. Scudder, who contributed the original chapters on Myriapoda, Arachnoidea and Insecta to the larger German work; "Handbuch der Paleontologie," vol. ii.

The figures, which are sharp and clean, are chiefly those of the original edition, though with many additions distributed through the work contributed by the American collaborators.

American students of Paleontology owe a debt of gratitude to the editor for his laborious task of rendering this classic work into the English language. They should also fully appreciate the courtesy shown by Professor Zittel to Americans in permitting such free translation of his work to be made; and particularly for allowing the insertion, in place of translation of the originals, of chapters written entirely by the American authors, with whose views he is not always in accord. W.

7. *Occurrence of Corundum in Canada.*—Volume viii, Part II, 1899, of the Report of the Bureau of Mines, published at Toronto, includes an interesting article by W. G. MILLER (pp. 205–240) on the corundum areas and the associated minerals of Ontario; this is a continuation of the discussion in the volume of the year before (this Journal, vii, 318). This report gives additional facts in regard to the distribution of corundum, and emphasizes its occurrence in igneous rocks of the following types: (2) syenite (mica, etc.); (2) syenite-pegmatite; (3) nepheline syenite; (4) anorthosite. Another paper on the same subject by Archibald Blue follows (pp. 241–249), while A. P. Coleman (pp. 250–253) describes a nephelite-syenite from Dungannon township, Hastings Co., which is remarkable for carrying numerous small

crystals of corundum, which stand out conspicuously on a weathered surface.

8. *A Manual of Zoology;* by T. JEFFREY PARKER and WM. A. HASWELL. 8vo, pp. 563, 327 cuts. New York, 1900 (The Macmillan Co.).—This smaller work is admirably adapted for the special use of young students, or for class-room work in preparatory schools and colleges. It is modelled, in general, after the larger Text Book of Zoology, by the same authors and publishers (1897), to which it forms a very suitable introduction.

In the present work much of the more technical matter of the larger work has been left out, and a number of the rarer or less known groups have been omitted, as well as the extinct fossil forms, in order to save space. Comparatively little space is given to histology and embryology, the object being to give a concise account of the structure and classification of the larger and more important groups, in harmony with the views of modern investigators. A. E. V.

9. *Reports on an Exploration off the West Coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of* ALEXANDER AGASSIZ, *by the U. S. Fish Commission Steamer Albatross, during 1891, Lieut. Com.* Z. L. TANNER, U. S. N., commanding—THE FISHES; by S. GARMAN. Memoirs of the Museum of Comparative Zoology, vol. xxiv, 4to, 1 vol. of text, with an atlas of 97 plates and a chart, December, 1897.

This is a grand contribution to oceanic ichthyology, which science owes to the well-known liberality of Mr. Agassiz and to the prolonged and careful studies of Mr. Garman. It is a worthy successor to the great work of Gaade and Bean on the Atlantic Deep Sea fishes. A large number of new genera and species are described, many of them remarkable in form and structure. The plates are admirable. Of these 14 are printed in colors. A. E. V.

10. *The Fur Seals and Fur Seal Islands of the North Pacific Ocean;* by DAVID STARR JORDAN, associated with LEONARD STEJNEGER, FREDERIC A. LUCAS, JEFFERSON F. MOSER, CHAS. H. TOWNSEND, GEO. A. CLARK, JOSEPH MURRAY, with special papers by twenty-five others. Washington, D. C. (Gov't Printing Office), 1898. Four Parts, with numerous plates and charts.—This is a nearly exhaustive work on the natural history of the fur seal, and of the present and past conditions of the fishery. It shows very clearly the rapid decline in numbers of the seals during recent years, due chiefly to pelagic sealing and the consequent starvation of large numbers of pups on the breeding grounds.

The report contains numerous special papers on the Zoology and Botany of the region, by about twenty-five specialists, besides those officially connected with the investigation.

Part IV by Mr. Stejneger, is devoted to the Asiatic Fur Seal Islands and their fisheries. It is illustrated by 108 plates and a number of charts. Part III contains much information in regard to pelagic sealing. It also has chapters on the fishes, birds, mammals, mollusca, crustacea, plants, etc., of the Pribilof Islands.

A. E. V.

11. *The Nature and Work of Plants: An Introduction to the Study of Botany;* by Daniel Trembly MacDougal, Ph.D., Director of the Laboratories, New York Botanical Garden. Pp. xvii+218. New York, 1900 (The Macmillan Company).—As the title indicates, the book before us deals with the functions of plants rather than with their structure. It is intended for the use of beginners who have no laboratory facilities at their disposal, and is written in simple language with the avoidance, so far as possible, of technical words. Most of the facts brought forward are illustrated by common plants and by experiments which can easily be made. In the first part of the book, attention is called to the general features of plants, to the various kinds of work which they perform, and to the division of labor resulting from the differentiation of the plant-body into organs and tissues. The functions of roots, leaves, stems and the different kinds of reproductive processes are then taken up with considerable detail and occupy the greater part of the volume. The last chapter deals briefly with ecology and includes descriptions of a few of the most characteristic plant-societies. A. W. E.

III. Astronomy.

1. *The Total Solar Eclipse of May 28th.*—The eclipse of May 28th, though of short duration, is so convenient for observation in the United States that a large number of observers will take the field. The line of totality in the United States is 1000 miles long, commencing at New Orleans, where it occurs at 7.27 A. M. and lasts for 1 minute 13 seconds, the central line passing through the suburbs of the city, and running off into the Atlantic at Norfolk, Va., where it occurs at 8.50 A. M. and lasts for 1 minute 42 seconds.

From the extensive researches of the Weather Bureau it appears that weather conditions are most favorable in the part of the track through North and South Carolina and Georgia, where on the eastern slopes of the Appalachians, at an elevation of about 1000 feet, the chances are six to one in favor of clear sky. Near the coast the chances are four to one, but the longer duration justifies the use of this region equally with the inland sites. Thus the Naval Observatory will send one party to Virginia Beach and another to North Carolina, while the party from Yerkes Observatory, consisting of Professors Hale, Barnard and Frost, will by invitation go also to Virginia Beach and work in coöperation with the Naval Observatory. For the most part, however, stations have not yet been definitely selected.

Both of these parties and also those from the Lick Observatory under Campbell and the Charbo Observatory under Burckhalter, will use photographic lenses of 40-foot focus for taking plates about 14×17 inches, on which the details of the corona can be presented on so large a scale as to avoid the necessity of further enlargement of the negative with the consequent loss of definition.

Campbell's photographs of this kind taken in India in 1898 are regarded as the finest ever made.

The eclipse committee appointed by the Astronomical and Astrophysical Society, Messrs. Newcomb, Hale, Barnard and Campbell, have issued a circular letter, under date of March 29, specifying in eleven classes the different lines of work that may be profitably undertaken, offering suggestions, in many cases quite minute, as to methods of work, and inviting the coöperation of all who intend to observe the eclipse.

The classification of work is as follows:

(1) Observations both direct and photographic of the relative position of the sun and moon for correcting the tables.

(2) Drawings of the corona made at the telescope, noting especially the structural features near large prominences and the general outline of the corona.

(3) The color of prominences.

(4) Photographs of the corona.

Attention is called to three classes of camera lenses which may be used for special purposes:

(*a*) Those of focal length about six times the aperture with a wide range of exposure, from $\frac{1}{100}$ up to 20 seconds, for recording the outer corona and extensions.

(*b*) Those of focal length about fifteen times the aperture with exposures from $\frac{1}{16}$ to 2 seconds, for recording the mid corona, inner corona and prominences.

(*c*) Those of relatively great focal length for recording the minute details of the structure of the inner corona.

Revolving diaphragms immediately in front of the plate, like the star used by Burckhalter in India, are recommended for reducing the brightness of the inner corona to the intensity of the mid region, whereby both can be photographed sharply with the same exposure.

(5) Photographic search for an intra-Mercurial planet.

(6) Distribution of "coronium" by testing visually and photographically the spectrum of different parts of the corona.

(7) Wave length of the green coronal line by photographs from a powerful spectrograph.

(8) Photographs of the "flash" spectrum at stations near the boundaries of the shadow path, including if possible a study of the dark line spectrum before the flash at first contact and after the flash at last contact.

(9) The heat radiation of the corona measured by the bolometer in the streamers and rifts and at various distances from the sun's limb.

(10) Photometric observations of the corona at various distances from the sun's limb, preferably photographic on account of the short duration of totality.

(11) Photometric observations of Mercury.

It is recommended that attempts be made to photograph the corona for as many seconds as possible before and after totality,

and photographers are cautioned to develop images slowly and to keep them as thin and transparent as possible, and to "back" all plates to prevent halation.

A matter beyond the scope of the circular but of much interest for spectroscopic work is the redetermination of the principal line of the corona. Professor Young has published a note calling attention to the important fact that the photographs made by Campbell and the English observers in India show that the old 1474 K line is in error. Special attention should be given to it in the coming eclipse. W. B.

2. *Total Eclipses of the Sun;* by Mabel Loomis Todd. Pp. 273. Revised edition. Boston, 1900 (Little, Brown & Co.).—No one on this side, or perhaps on either side, of the Atlantic has labored more or traveled farther in eclipse work than Professor Todd.

His wife has shared his travels and to some extent his labors, and has supplemented them by a volume written in a thoroughly scientific spirit and in the "handy science" form. The special merits of the book have been noticed at its first appearance. The second edition is opportunely brought out while interest is aroused in this country by the coming eclipse of May, and brings the work down so as to include the eclipses of '96 and '98 observed in Nova Zembla and India.

IV. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The spring meeting of the National Academy was held at Washington from April 17th to 19th. The President, Dr. Wolcott Gibbs, presided. The list of papers accepted for reading is as follows:

S. F. Emmons: Secondary enrichment of sulphides in ore deposits.

A. Agassiz: The cruise of the U. S. Fish Commission Steamer "Albatross" in the South Seas, August, 1899 to March, 1900.

Theodore Gill: On the Zoogeographical relationships of Africa.

Simon Newcomb: Report of the Watson trustees on the award of the Watson medal to David Gill.

F. W. Putnam: A human bone from the glacial deposit at Trenton, N. J.

L. E. Griffin: The anatomy of *Nautilus pompilius.*

J. E. Duerden: West Indian Madreporarian polyps.

Reginald A. Fessenden: On the use of electric motors, of the shunt type, for solving linear differential equations of any order with variable coefficients. On the prediction of the physical properties of the pure metals.

Rollin A. Harris: A partial explanation of some of the principal tides.

The following gentlemen were elected members of the Academy: James E. Keeler of the Lick Observatory, Mt. Hamilton, California; Henry F. Osborn and Franz Boas of Columbia University, New York City; Samuel F. Penfield of Yale University, New Haven. The Academy was entertained by the Washington Academy of Sciences on Wednesday evening the 18th. The autumn meeting is appointed for November 13th at Providence, R. I.

2. *Proceedings of the Washington Academy of Sciences*, vol. i, pp. xiv, 347; Plates XXVI.—The first volume of the Proceedings of the Washington Academy of Sciences has recently been issued. It contains, besides administrative matters, a series of valuable papers. The first of these is a revision of the Squirrels of Mexico and Central America, by E. W. Nelson; another gives a synopsis of Mexican and Central American Umbelliferæ, by J. M. Coulter and J. N. Rose; an important paper by Lester F. Ward (noticed in the present number, p. 384) describes a new genus and twenty new species of the fossil cycads from Wyoming; a paper by C. D. Walcott on the Lower Cambrian Terrane of the Atlantic Provinces was noticed in the April number (p. 302).

3. *Report of the Superintendent of the United States Coast and Geodetic Survey, showing the progress of the work from July 1st, 1897, to June 30th, 1898.* Pp. 489, 4to, with numerous maps and plates. Washington, 1900.—The present volume is the sixty-seventh annual report issued by the Coast Survey Bureau, now under the charge of Prof. H. S. Pritchett. It contains the usual administrative report and in addition a series of appendices by various members of the scientific corps of the Survey. Three of these contain altitude determinations by means of spirit leveling between Salina, Kansas, and Colorado Springs; another discusses determination of time, longitude, latitude, and azimuth; still another the salinity and temperature of certain parts of the Pacific Ocean.

4. *Vertical Gradients of the Temperature, Humidity, and Wind Direction. A Preliminary Report on the Kite Observation of 1898.* Prepared under the direction of Willis L. Moore, Chief of the U. S. Weather Bureau, by H. C. FRANKENFIELD. Washington, 1899. (U. S. Department of Agriculture, Weather Bureau, Bulletin F.)—This volume is a striking illustration of the advance made in meteorological methods in recent years by the use of kites. The opening pages by Prof. C. F. Marvin describe the construction of the kites found to be most useful, the method of using them, and the meteorograph employed.

5. *The Theory and Practice of Interpolation;* by HERBERT L. RICE, M.S., of the American Ephemeris. Pp. 234, 4to. Lynn, Mass., 1900 (The Nichols Press).—A treatise of much value for computers. The author has collected for the first time, from all sources since Newton, everything of value relating to differences, interpolation, tabular differences, and mechanical quadrature with many processes and developments, original if not altogether new. Eight tables, including Newton's, Sterling's and Bessel's coefficients, a large number of illustrative examples and a full bibliography add greatly to the usefulness of the book. W. B.

6. *Irrigation and Drainage; Principles and Practice of their Cultural Phases;* by F. H. KING. Pp. 1–492; New York, 1900. (The Macmillan Co.)—This last volume in the Rural Science Series is a well written, well illustrated discussion of the relation

of soil moisture to plant life. It bears the marks of careful investigation, yet is written in untechnical language and is just such a book as should interest and aid those engaged in any form of soil tillage. H. E. G.

7. *Mesure des Températures élevées;* par H. LE CHATELIER et O. BOUDOUARD, pp. 220, 8vo. Paris, 1900, Bibliothèque de la Revue générale des Sciences (Georges Carré et C. Naud).—The measurement of very high temperatures is always a matter of great interest, whether viewed from the purely physical standpoint or from the technical side. The early experiments of Wedgwood, dating back more than one hundred years, form a starting point in the development of the subject, while the recent experiments of Chatelier, Barus, Holborn and Wien, and others show how much may be accomplished in this direction. The present volume is a very useful and compact résumé of the entire subject, taking up the various forms of pyrometers in succession, according to the physical principles involved in each. The whole forms a most interesting discussion, and brings out clearly the point which science has now reached as well as the limitations of the present methods. The author notes that in order to reach a higher degree of precision than has been yet attained, a more exact determination of the fixed points serving for the graduation of the pyrometer is much to be desired; since, for example, the points of fusion of zinc, silver, and gold are still uncertain to some ten degrees. Furthermore, a more precise determination of the relation between the electrical resistance of platinum and the temperature is needed; while for the very highest temperatures it would be useful to have a more definite knowledge of the laws of radiation of an absolutely black body. The work is well brought up to date and includes, for example, the experiments of Holborn and Wien (1896), although the later papers by Holborn and Day, of a year ago, with their important results, are not mentioned.

OBITUARY.

Dr. THOMAS PRESTON died at his home in Dublin on March 7 at the early age of forty years. His works on the "Theory of Light" (1890) and the "Theory of Heat" (1895) gave him a high place among writers in Physics, while his papers, following Zeeman, on radiation phenomena in a magnetic field (1897, 1899) showed that he was an investigator of a high order.

Mr. GEORGE JAMES SYMONS, the well known English meteorologist, died on March 10, at the age of sixty-two.

Dr. ST. GEORGE MIVART, the distinguished English biologist, died on April 1st at the age of seventy-three. Some of his prominent works are: "On the Genesis of Species" (1871); "Lessons in Elementary Anatomy" (1873); "Nature and Thought" (1882).

Dr. WILHELM WAAGEN, Professor of Paleontology at the University of Vienna, died on March 24 in his fifty-ninth year.

Professor ÉMILE BLANCHARD, the celebrated French zoologist, died at Paris in February at the age of eighty-four.

PROFESSOR OLIVER PAYSON HUBBARD died at his home in New York City, on March 9th, in his ninety-first year. His long life spanned nearly the whole of the century now closing, and his death thus takes away almost the last survivor of the group of teachers who were actively interested in, and engaged in promoting, the first beginnings of science in this country.

He was born at Pomfret, Conn., in 1809, but his youth, after 1811, was spent at Rome, N. Y. He entered Hamilton College, in Clinton, N. Y., in 1825, and a year later joined Yale College, where he was graduated with the class of 1828. Of this class he was the last survivor. After graduation he spent three years in teaching and from 1831 till 1836 was assistant to Professor Benjamin Silliman in the Yale Chemical Laboratory. Of his work here, Professor Silliman speaks as follows: "Mr. Hubbard remained with me five years, and his services were very important. His intelligence and gentlemanly bearing made him very acceptable to the strangers who often called upon us. He was also highly acceptable to the students, whom he treated with affability and kindness. His punctuality, his exactness in affairs, and perfect integrity, made him entirely reliable, while his knowledge of science in all the branches that belonged to the department qualified him to render efficient assistance."

In 1836 he was appointed to the Professorship of Chemistry, Mineralogy and Geology in Dartmouth College, at Hanover, N. H., retaining that position for thirty years. He resigned the work of that chair in 1866, but retained his lectures in the Medical School connected with the college until 1883, when he was made Professor Emeritus. Professor Hubbard was one of the founders of the American Association for the Advancement of Science in 1848, and was Secretary, Vice-President and later President (1892–93) of the New York Academy of Sciences. He was also one of the founders of the Association of American Geologists and Naturalists. He was keenly interested in a wide range of subjects in chemistry, mineralogy and geology, also in geography and in medicine; this interest remained unabated up to the close of his life. Early papers by him, published in this Journal (1837) describe the calcareous rocks of Boonville, N. Y., with the minerals and bowlders of the same locality; another paper (1838) gives the results of geological observations in the White Mountains; still another (1842) is on a chemical examination of the bituminous coal of Chesterfield County, Va. He received the degree of M.A. from Yale and Dartmouth, of M.D. from South Carolina Medical College and of LL.D from Hamilton College.

Professor Hubbard was married May 17, 1837, to Faith Wadsworth, daughter of Prof. Benjamin Silliman; she died in 1887. Two children survive him. From 1874 until his death he made his home in New York City; the bright, genial serenity of his declining years made him a charming companion to all who had the opportunity to meet him.

BEAUTIFUL MONTANA AMETHYSTS.

A new and quite inaccessible locality in Montana is now producing some uncommonly interesting varieties of Quartz. These were briefly described in the February "*Mineral Collector*," by A. C. Bates. The most attractive are the beautiful, richly colored Amethysts. Loose crystals and small groups, 5c. to 50c.; groups of crystals in parallel position, uncommonly choice, 50c. to $3.50.

REMARKABLE ENCLOSURES OF TOURMALINE.

Associated with the Montana Amethysts are singularly excellent specimens of Quartz crystals enclosing needles of Tourmaline. The crystals range from 2 inches to 4½ inches in length, and are at times so densely filled with the tourmaline needles as to render the whole crystal black and opaque, while again the needles will be but sparsely scattered through the crystal and each can be readily seen. We have a fine assortment of both single crystals and groups, at 25c. to $2.50. Among the most desirable specimens from this new locality are the crystals showing rich amethyst tips on the black tourmaline-quartz crystals.

In addition to the lot of ninety specimens already on sale a second and larger shipment is en route and will probably be on sale by May 1st and the entire output of the locality has been contracted for.

A NEW LOT OF SILICEOUS CALCITES

Has just arrived from South Dakota, all of them in small sizes. Many excellent doubly-terminated crystals are in this lot at 15c. to $1.00. Groups, 25c. to $2.50; museum-size groups, $2.50 to $15.00. Professor Penfield's paper in the current number of the American Journal of Science will add greatly to the interest in these specimens.

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Over 200 choice groups of Epidote crystals on the matrix, and over 700 loose crystals have been recently received, 5c. to $3.00.

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Several strikingly fine **twisted Smoky Quartz.**

Splendid **"Iron Rose,"** octahedral **pink Fluorite,** fine **Brookites, Octahedrites, Adularia, Sphene, etc.**

Prices range from $3.50 to $75.00, many of the specimens being worth $12.50 to $20.00, and on up to $65.00 and $75.00.

A FEW OF THE MANY OTHER RECENT ADDITIONS.

Leonite, new and excessively rare, one loose crystal, $7.50.

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Graftonite, described in Jan. A. J. S., 50c. to $3.50.

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Chas. D. Walcott,
U. S. Geol. Survey.

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[FOURTH SERIES.]

ART. XXXVIII.—*On a Method of Studying the Diffusion (Transpiration) of Air through Water, and on a Method of Barometry;* by C. BARUS.

1. SMALL bubbles of air in a mass of liquid gradually vanish in the lapse of time, if a very high pressure is persistently maintained. Air forced into the liquid in accordance with Henry's law diffuses into less aërated surroundings, becomes dissipated and too far diluted to reappear on removal of pressure. The experiment, though interesting, does not lend itself to computation.

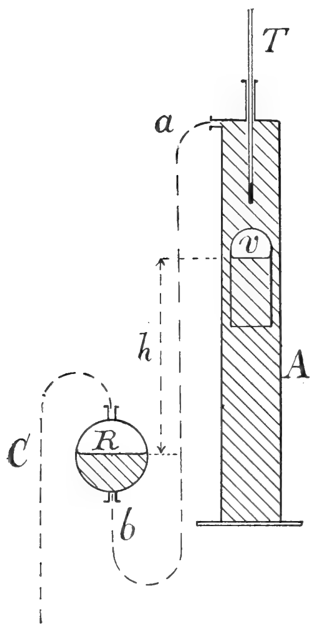
I purpose in the following to describe a method of inducing the transpiration of air through a wall of water under known conditions, seeing that few data on this subject have yet been investigated. It is not impossible that from data of this kind one may estimate the degree of physical porosity of the liquid; to state, in other words, what fraction of the area of a normal interface is permeable, and what fraction impermeable to a current of gas.

The physical laboratory is in possession of a Cartesian diver, made by Prof. Blake some years ago. I have been exhibiting this yearly since 1895, and as it seems to me, the diver has been becoming steadily heavier in this course of years: at least, whereas at the outset the diver was usually afloat, it is so now only under exceptionally high temperature and low barometer. The question therefore occurs whether there is any reason for the loss of air in v (see figure), if the top of the jar is slightly open and in contact with the atmosphere, after the diver has been permanently sunk. Clearly such a reason does exist, at least qualitatively, for the air in v is under atmospheric pressure plus the additional pressure due to the head of

water, equal to the height of A. There is thus a continual tendency to squeeze out the air from v through the pores of the water into the atmosphere, which in the lapse of years may very well produce a definite effect.

Obviously, merely the head of water stated induces diffusion; for change of atmospheric pressure is without differential effect. Great pressure-excess at v may be secured by increasing this head, but the distance through which the imprisoned air will have to diffuse to escape into the air is correspondingly lengthened. Pressure-excess at v for a given head may be incremented by virtually making the water heavier; and this may be done by putting the jar A into a centrifugal machine, in which case the transpiration would still take place under known conditions.

1



2. A method of accurately measuring the gas in v is next to be devised. This is accomplished if a sensitive thermometer, T, and a reservoir, R, joined by rubber tubing to A for producing a variable atmosphere, is added as suggested in the figure. For reasons stated (diver sunk), the vessel, R, in the following experiments is depressed. This is objectionable since there is some danger of parting the column of water in the rubber tube with influx of air if the thermometer, T, is to be moved up and down. A floating diver and raised vessel, R, constitute a better disposition. Instead of the divided vessel, A, R, a single tube about 6 feet long and a diver usually floating at the middle would answer all requirements; but the temperature-distribution in so long a tube would be liable to introduce serious errors. Finally R is provided with a special piece of rubber tubing, C, through which pressure increments or decrements may be applied temporarily by the mouth.

Before beginning a series of measurements, suction and pressure are applied alternately at C, causing the diver to move up and down throughout A (T raised), until the temperature, nearly uniform before, has become quite so. Care must be taken to avoid violent motion. Thus with a differential suction of half an atmosphere, the adiabatic change of tempera-

ture in v is, at 20° and one atmosphere, about 3·6°. Even if the diver falls quietly to the bottom of the vessel of about a foot in height, the temperature-increment is adiabatically ·23°. Good measurement, on the other hand, requires that the temperature of v should be known to at least ·1° C. R is so placed that the diver permanently floats at the top and remains permanently sunk at the bottom of A. Very slight suction and pressure alternating now suffice to find the level of unstable equilibrium. After some practice this adjustment may be made within a millimeter. A steel ring sliding on A (kept in vertical position) will indicate this position, so that the head, h, may afterwards be read off at pleasure by the cathetometer or directly. Immediately after finding the level in question it is best to sink the thermometer into the region to get its temperature.

The conditions of floatation here involved follow roughly from hydrostatics and Boyle's law, viz:

$$h+H\frac{\rho_m}{\rho_w}=\frac{R}{g}\frac{m}{M}\frac{\tau}{(1+m/M)-\rho_w/\rho_g}, \qquad (1)$$

where H is the height of the barometer at 0° C., ρ_m the normal density of mercury, ρ_w that of the head of water, h. Furthermore R is the gas constant, m the mass and τ the absolute temperature of the gas in v, M the mass and ρ_g the density of the walls of the diver. The temperature in h is taken as the same as that of the water in A. Equation (1) is for dry gases; for wet gases $p'/\rho_w g$ is to be added, if p' is the vapor pressure of water.

It will be at once seen that there are grave objections against making the float of glass: in such a case the temperature, τ, cannot be accurately found, and this is the critically important datum. A metal vessel is therefore preferable, in which case moreover the value ρ_w/ρ_g will be small enough to make the coefficient of τ in an empirical equation constant. Unfortunately the level of the inclosed liquid is not at once given. The temperature discrepancy also requires the exclusion of bulky non-conducting air masses in v. Other conditions of sensitiveness are obvious.

If air diffuses out of the apparatus, m/M will decrease; in other words, the coefficient of temperature, t, in the empiric equation

$$h+H\frac{\rho_m}{\rho_w}=A+B\,(t-20), \qquad (2)$$

modeled after (1), i. e., B will decrease. A is a constant and observations are taken near 20° C. Now B can be found with ease from an even number of measurements by differences,

since at constant H, it is merely the rate at which h varies with t, the temperature of the air in the float.

This is the method which I have adopted. It depends for its success chiefly on the determination of t, so that slow work, avoiding the thermal effects of adiabatic expansion, is presupposed. After standardizing the vessel it is to be put away to be examined in the lapse of years.

The following data were obtained in the standardization in question:

H, observed. cm. 0° C.	h. cm.	t. 0° C.	A.	B.	H, computed. cm. 0° C.
77·25	−76·83	17·2	985·4	5·27	77·02
·27	−67·45	19·6			·26
·28	−57·45	21·5			·26
·24	−49·75	22·8			·20
·21	−43·60	24·1			·25
·21	−37·95	25·0			·18
·21	−32·27	26·2			·23
·21	−24·94	27·6			·24

The errors encountered in this work are shown by the comparison made of H. The first datum observed is wrong for some special reason, probably the column h parted. The remainder show a fair order of agreement, remembering that with a glass float, at a temperature different from that of the atmosphere, it is impossible to get the temperature of the air in the float accurately by mere waiting.

3. In spite of the unfavorable conditions of experiment, it is interesting to note that the arrangement given is a water barometer, which instead of being upwards of 30 feet long, consists of two ordinary vessels. I have not thought it worth while to look up the literature of barometry, but it is hardly probable that a device like the above has been left untried. I will merely remark that if a barometer is made in this way, the metallic float should either be annular so as to encircle the thermometer, T, when observations are made, or the thermometer should be an integral part of the float. In the above vessel, for instance, a temperature error of 1° C. corresponds to $\cdot 39^{cm}$ of mercury, so that the temperature reading must be vouched for to about ·025 C., if the barometer is to be correct to 1/10 millimeter. A table of double entry, or a chart, would then give H for the arguments h and t as shown.

Brown University, Providence, R. I.

ART. XXXIX.—*The Separation and Determination of Mercury as Mercurous Oxalate;* by C. A. PETERS.

[Contributions from the Kent Chemical Laboratory of Yale University—XCIV.]

IT is stated in the literature* that oxalic acid, neutral and acid oxalates of the alkalies, precipitate mercurous salts, and that oxalic acid and the double oxalates of potassium produce no precipitate with mercuric chloride solution. Starting with these facts, the attempt was made to estimate mercurous salts: volumetrically, by precipitating with ammonium oxalate and determining the oxalic acid by potassium permanganate; and gravimetrically by direct weighing of the precipitate.

The Volumetric Estimation.

The mercurous nitrate solution used was standardized by the battery, and contained about 12 gms. of metallic mercury to the liter. To obviate the tendency of the mercury salt to break down and form basic salts† upon the addition of a large amount of water if no nitric acid is added, the solution was prepared in the following manner. About 20 gms. of mercurous nitrate were ground in a mortar, transferred to a flask, and 200–300$^{cm^3}$ water added. After shaking well, the solution was filtered and the filtrate diluted to one liter. Five cm^3 of this solution when precipitated with a sodium chloride solution gave a filtrate from which only a very slight darkening in color could be obtained, even upon several hours standing, when treated with hydrogen sulphide, thus showing the absence of a mercuric salt.

A solution made in the above manner had not changed its standard after a period of eight weeks. The potassium permanganate solution (approximately $\frac{n}{10}$) was standardized against lead oxalate.

It was first attempted to estimate the mercurous salts as follows. The mercurous oxalate was precipitated cold by means of ammonium oxalate, stirred well, and allowed to settle, the completion of the precipitation being determined by addition of more ammonium oxalate. The precipitate was collected on asbestos, washed once or twice with cold water, and (still in the crucible) treated in a beaker with 5$^{cm^3}$ of strong hydrochloric acid. To the solution diluted to 100–200$^{cm^3}$ 1 gm. of a manganous salt was added, and the oxalic acid was titrated with permanganate at the ordinary temperature of the room. The end color was not stable and was hard to determine. Three experiments, using 0·1217 of

*Rose und Finkener, Handbuch der Analytischen Chemie, i, 319.

†Graham Otto, Handbuch, iii, 1102.

mercury in form of mercurous nitrate, gave plus errors of 0·0011 gms., 0·0017 gms. and 0·0028 gms. respectively, or 1·5 per cent. The precipitate when dissolved in sulphuric acid and titrated gave no better results. To obviate this difficulty the ammonium oxalate solution was matched on the permanganate and the oxalic acid in the filtrate determined. The results obtained by this method, given in the following table, are quite accurate.

	Hg taken as $Hg_2(NO_3)_2$ gms.	Hg found. gms.	Excess of ammonium oxalate app. $\frac{n}{10}$ cm^3	HCl Sp. gr. 1·16 cm^3	$MnCl_2.4H_2O$ gms.	H_2SO_4 1:1 cm^3	Error as Hg
				A			
1	0·1825	0·1823	0·90	5·	·5	----	−0·0002
2	0·1217	0·1218	0·93	5·	·5	----	+0·0001
3	0·1217	0·1206	0·99	5·	·5	----	−0·0011
4	0·1217	0·1210	4·05	5·	·5	----	−0·0007
5	0·3042	0·3034	4·97	5·	·5	----	−0·0008
				B			
6	0·1217	0·1220	0·93	----	----	5	+0·0003
7	0·1217	0·1211	0·97	----	----	5	−0·0006
8	0·1825	0·1827	0·89	----	----	5	+0·0002
9	0·3042	0·3040	0·82	----	----	5	−0·0002
10	0·1217	0·1202	4·10	----	----	5	−0·0015

In the experiments recorded in section A of the table the filtrate was titrated in the presence of hydrochloric acid and a manganous salt, at a temperature of 20°–40°.* In the experiments under section B sulphuric acid was added and the solution heated in the usual manner. An excess of ammonium oxalate as shown in exps. 4, 5 and 10, interferes in no way.

The separation of mercurous salt from small quantities of mercuric salts, by the means of dilute nitric acid, sp. gr. 1·15, was next attempted. It is stated† that mercurous oxalate is insoluble in cold dilute nitric acid, while mercuric oxalate is more or less soluble in the same reagent. Before attempting any separation, however, there are three factors with reference to the action of the nitric acid which need to be determined—first, the maximum amount of nitric acid that may be present in titration of an oxalate without interference; second, the maximum amount of nitric acid that may be present in a precipitation of mercurous oxalate without having any perceptible solvent action upon the same; and, third, the amount of mercuric oxalate which will be held in solution by given amounts of nitric acid.

* Gooch and Peters, this Journal, vii, 461, 1899.
† Souchay and Lenssen, Ann. d. Chem., cii, 43.

To determine the amount of nitric acid that may be present in the titration of an oxalate, 10^{cm^3} of $\frac{n}{10}$ ammonium oxalate were titrated with permanganate at a dilution of 100^{cm^3} with sulphuric acid at 80° C. The event proved that 10^{cm^3} of nitric acid, sp. gr. 1·15, may be present without appearance of interfering action. The maximum amount of nitric acid which may be present without action upon the mercurous salt was determined as shown in the following experiments.

Hg taken as $Hg_2(NO_3)_2$ gms.	Excess of ammonium oxalate approximately $\frac{n}{10}$ cm^3	HNO_3 Sp. gr. 1·15 cm^3	Volume at precipitation	Hg found gms.	Error.
0·1122	1·64	10	100	0·1087	−0·0035
“	2·62	6	“	0·1098	−0·0024
“	1·59	6	“	0·1096	−0·0026
“	1·53	5	“	0·1109	−0·0013
“	1·40	5	“	0·1134	+0·0012
“	1·50	5	“	0·1115	−0·0007
“	1·70	4	“	0·1116	−0·0006
“	1·59	8	200	0·1096	−0·0036
“	6·62	8	“	0·1111	−0·0011
“	7·72	8	“	0·1108	−0·0014
“	2·59	5	“	0·1107	−0·0015
0·1010	2·07	5	“	0·1003	−0·0007

Working under the conditions stated in the above table, it is plain that 5^{cm^3} of nitric acid, sp. gr. 1·15, may be used before its solvent action is sufficient to interfere with the accuracy of the process.

To determine the amount of mercuric salt that would be held up by 5^{cm^3} of nitric acid, sp. gr. 1·15, the following experiments were made.

Hg taken as $Hg_2(NO_3)_2$ gms.	HNO_3 Sp. gr. 1·15 cm^3	Ammoninm oxalate $\frac{n}{10}$ cm^3 in excess	Volume cm^3	Time before precipitation.
0·0335	4	0·75	100	5 hours.
0·0095	4	1·00	100	No. ppt. 20 hours
0·0143	5	6·5	100	“
0·0238	5	1·5	100	Slight ppt. 20 hours
0·0238	5	5·5	100	25 minutes.

Five cm^3 of dilute nitric acid (sp. gr. 1·15) will prevent the precipitation of small amounts of mercuric salt, 10–20 mgms. calculated as mercury, depending upon the amount of ammonium oxalate present in excess. This amount of nitric acid has no apparent solvent action on a precipitate of mercurous oxalate under conditions already stated and does not interfere

with the titration of an oxalate by permanganate as already shown.

Carrying out the process of separation of mercurous from mercuric salts, the precipitation was made as described for the estimation of mercurous salts alone, excepting that nitric acid and mercuric salt were added. The experiments in A, B, and C, of the accompanying table show the amounts of mercuric salt from which the mercurous oxalate may be separated with 2^{cm^3} of nitric acid. In experiments in section A the results are quite accurate, but an excess of ammonium oxalate tends to increase the results a little as seen in experiments under B. An increase in the amount of mercuric salt present causes also, as shown in section C, the results to be a trifle high.

	Hg taken as $Hg_2(NO_3)_2$ gms.	$Hg(NO_3)_2$ present calculated as Hg. gms.	Ammonium oxalate app. $\frac{n}{10}$ in excess. cm^3	HNO_3 Sp. gr. 1·15 cm^3	Volume at precipitation.	Hg found. gms.	Error.
A	0·1217	0·0067	0·86	2	100	0·1232	—0·0015
	"	"	0·92	"	"	0·1220	+0·0003
	"	"	0·97	"	"	0·1218	+0·0001
	"	"	0·90	"	"	0·1224	+0·0007
	"	"	0·91	"	"	0·1213	—0·0004
B	0·1221	"	3·92	"	"	0·1237	+0·0016
	0·1217	"	3·93	"	"	0·1235	+0·0018
	0·1242	"	8·75	"	"	0·1263	+0·0021
C	0·1217	0·0134	0·87	"	"	0·1230	+0·0013
	"	"	0·86	"	"	0·1232	+0·0015
D	"	"	3·93	4	"	0·1218	+0·0001
	"	"	3·90	"	"	0·1211	—0·0006
E	0·2244	0·0067	1·88	"	115	0·2244	±0·0000
	"	"	1·91	"	130	0·2240	—0·0004
EE	"	0·0141	2·98	"	100	0·2230	—0·0014
	"	"	2·94	"	"	0·2241	—0·0003
F	"	0·0067	8·88	"	"	0·2289	+0·0045
	"	"	8·90	"	"	0·2285	+0·0041
G	0·2424	"	1·75	"	200	0·2432	+0·0008
	"	"	2·00	"	"	0·2414	—0·0010
	"	"	2·96	"	"	0·2421	—0·0003
H	0·2245	0·0134	1·74	"	"	0·2271	+0·0026
	"	"	1·81	"	"	0·2256	+0·0012
I	0·1122	0·0144	6·62	5	"	0·1121	—0·0001
K	"	0·0240	6·54	5	"	0·1136	+0·0014
	"	"	6·57	5	"	0·1130	+0·0008

In experiments D, using 4^{cm^3} of nitric acid even in the presence of an excess of ammonium oxalate, the results are accurate. In experiments E the amount of mercurous salt

was doubled and the results are accurate. In EE the amount of mercuric salt was also doubled and the results are still fairly accurate; but when a large excess of ammonium oxalate is present as in experiments F, even with the smaller amount of mercuric salt, the results are high. At a dilution of 200^{cm^3} the results are normal as seen in experiments G; but the introduction of more mercuric salt, as in experiments H, causes a plus error.

Using 5^{cm^3} of nitric acid, the larger amount of mercuric salt, together with a large excess of ammonium oxalate, as recorded in experiments K, the error is raised a trifle; but with a smaller amount of mercurous salt as in experiment I the result is normal.

In precipitating mercurous salts by ammonium oxalate $\left(\frac{n}{10}\right)$ it is an easy matter to keep the excess of the precipitant within the limits of 1 or 2^{cm^3}, because the mercurous oxalate, when properly stirred, settled very rapidly.

The Gravimetric Estimation.

All the conditions described above in the volumetric estimation of mercurous oxalate, for the separation of mercurous from mercuric salts, may be applied to the gravimetric estimation of mercurous oxalate. The precipitate is collected on a weighed asbestos filter, washed two or three times with cold water and dried over sulphuric acid to a constant weight. Amounts of mercurous oxalate equivalent to 0·1217 and 0·2244 gms. of metallic mercury dried to a constant weight over sulphuric acid in about 15 hours; a larger amount equivalent to 0·3 gm. of metallic mercury, required about 2 days to dry to a constant weight. Souchay and Lenssen* state that mercurous oxalate breaks up at 100°; consequently this temperature cannot be used for drying. For example, a precipitate containing 0·1122 gms. mercury as the oxalate which when brought to a constant weight at the ordinary temperature over sulphuric acid weighed 0·1371 gms., and was heated and weighed as follows:

After 7	hours	at 110°,	weight	=	0·1338 gms.
" 2	"	"	"		0·1328 "
" 7	"	"	"		0·1302 "

The result shows a loss of 0·0069 gms. for 16 hours heating, and agrees with the statement of Souchay and Lenssen.

The following experiments give the results of the gravimetric work, in which the drying was effected, by exposure for 15 hours or less, at ordinary temperatures, over sulphuric acid. The larger amounts of nitric acid present in the separations cause the precipitate to be more granular and aid in the filtering process.

* Ann., ciii, 308.

	Hg taken as $Hg_2(NO_3)_2$ gms.	Hg present as $Hg(NO_3)_2$ gms.	Excess ammonium oxalate present app. $\frac{n}{10}$ cm³	HNO_3 Sp. gr. 1·15 cm³.	Volume at precipitation cm³.	Hg found. gms,	Error. gms.
K	0·1217	----	2–4	----	100	0·1217	±0·0000
	"	----	"	----	"	0·1217	±0·0000
	0·1122	----	"	----	"	0·1124	+0·0002
L	"	0·0067	0·93	2	"	0·1130	+0·0008
	"	"	0·93	"	"	0·1112	−0·0010
M	"	"	4·40	"	"	0·1124	+0·0002
N	"	0·0135	0·72	4	"	0·1125	+0·0003
O	0·2244	0·0071	1·68	"	"	0·2253	+0·0009
	"	"	2·46	"	"	0·2241	−0·0003
P	"	0·0048	0·54	"	200	0·2248	+0·0004
	"	"	2·44	"	"	0·2245	+0·0001

In section K are experiments showing the accuracy of the process where a mercurous salt is precipitated in the absence of a mercuric salt. A small amount of mercuric salt was introduced in experiments L, and an excess of ammonium oxalate in experiment M, a still larger amount of mercuric salt was present in experiment N, and a larger amount of mercurous salt in experiments under O. In experiments in section P a dilution of 200$^{cm^3}$ was employed both with and without an excess of ammonium oxalate. All the results are within reasonable limits of error.

The work may be summed up briefly as follows: Mercurous nitrate may be estimated volumetrically by precipitating as the oxalate and determining the excess of the precipitant with permanganate.

The precipitated mercurous oxalate may also be estimated gravimetrically by drying it over sulphuric acid and weighing directly.

In solutions containing 2–5 per cent dilute nitric acid, sp. gr. 1·15, mercurous salts may be separated quantitatively as the oxalate from small quantities of mercuric salts.

If about 0·12 gm. of mercury is present as the nitrate in 100$^{cm^3}$ of water, about 12 per cent of that amount of mercury as the mercuric salt may be present without interfering with the accuracy of the estimation, and even 20 per cent may be present before an appreciable rise in the result is apparent. If the amount of mercurous salt present is doubled, the amount of mercuric salt which may be present is cut down about one-half.

The author wishes to thank Professor F. A. Gooch for many kind suggestions given during the course of this work.

Art. XL.—*Electrical Resistance of Thin Films Deposited by Cathode Discharge*; by A. C. Longden.

More than twenty years ago, a method of depositing metallic films upon glass, by means of electrical discharge in exhausted tubes, was devised by Professor A. W. Wright* of Yale University. This physicist not only described a method of producing the films, but he pointed out the peculiar brilliancy of their mirror surfaces and their colors by transmitted light. He also noted the rate of deposition of the different metals, and suggested that as aluminum and magnesium were deposited very slowly, these metals should be used as electrodes in vacuum tubes, in order to prevent the discoloration of the glass in the neighborhood of the cathode, which was so common when platinum electrodes were employed.

During the past two years I have been investigating the electrical resistance of thin films deposited by a modification of Professor Wright's process.

Quite early in this investigation it was observed that very thin films have enormously high electrical resistance,—very much higher, as compared with thicker films of the same kind, than their thickness would seem to indicate. It was also observed that, in many cases, temperature changes did not produce such variations in electrical resistance as are common in ordinary wire resistances.

As early as April 30, 1898, careful measurements of the resistance of a particular platinum film at different temperatures, revealed the fact that its temperature-coefficient was negative, its value being $-0{\cdot}00013$. Numerous measurements which have been made since that time, fully warrant the statement that all very thin films have negative temperature-coefficients, and that films within a certain range of thickness have zero or negligible temperature-coefficients.

A peculiar relation is found to exist between the magnitude of the temperature-coefficient of a film resistance, and the process of artificial ageing. If a film be placed in a bath of melted paraffin or hot oil, and measured while in the bath, its resistance is usually found to change quite rapidly at first, and then gradually less rapidly for a considerable length of time. If the first rapid change is an *increase*, a maximum is soon reached, and then follows a gradual and long continued *decrease*. In such a case, the temperature-coefficient is positive. If, however, the first change is a *decrease*, the later and more gradual change is an *increase*. In such a case as this, the

* This Journal, vol. xiii, pp. 49–55, 1877. Ibid., vol. xiv, pp. 169–178.

temperature-coefficient is negative. If the resistance does not change at first, it will not change at all. In such a case the temperature-coefficient is of course zero. A small temperature-coefficient is therefore desirable, not only for its own sake, but because a film resistance having a small temperature-coefficient does not require much artificial ageing; and because such a resistance is exceedingly reliable after the ageing process is finished.

Film resistances, after artificial ageing, should be protected from the atmosphere. The necessary protection may be afforded in any one of a variety of ways. The film may be sealed in a vacuum tube, it may be embedded in paraffin, or it may be coated with a varnish prepared by dissolving india-rubber in carbon disulphide.

In the early part of this investigation, the electrical contacts between the films and their terminal wires gave no small amount of trouble. Clamped contacts were unsatisfactory, both on account of the delicacy of some of the very thin films, and on account of the tendency of the oil or paraffin to force its way into the joints during the process of artificial ageing.

To overcome these difficulties, several methods of making electrical connections were devised. The one which was most used, consisted in depositing very thick films of negligible resistance upon the *ends* of the thin resistance films. Terminal wires were then wound on, and the joints between the wires and the thick ends of the films were permanently secured by the electrolytic deposition of copper and silver upon them.

These resistances, when properly prepared, are not to be classed with carbon resistances, but may be regarded as standards of a very high degree of accuracy. They may have any desired value, from a few ohms up to several megohms. They may be made of pure metals and thus be free from the danger of disintegration which is so common in alloys; and the metals chosen may be such as are least affected by external influences. In addition to these valued qualities as pure metals, they possess the only advantages of alloys, namely, high resistance and low temperature-coefficients. After suitable artificial ageing and subsequent protection from the atmosphere, they may be regarded as perfectly trustworthy standards.

It is important, however, that the artificial ageing process should be thorough. Otherwise the gradual change in resistance which the films are undergoing may continue for several months.

I append a few records for the purpose of presenting the results of perfect and imperfect artificial ageing. The results given in the successive columns of the table are for measurements made at intervals of about a month. They are for

measurements either made at the same temperature, or reduced to the same temperature; the temperature-coefficients of the several films having been carefully determined.

These records are exhibited in three classes. In class C, where the films were imperfectly aged, the variations during the first month amounted to several per cent, and even during the third month were as much as two- or three-tenths of one

	Numbers.	Resistances in ohms.			
Class A.	1.	2265·8	2265·7	2265·8	2265·8
	2.	37586·	37585·	37588·	37586·
Class B.	3.	384·90	383·72	383·16	382·92
	4.	9999·5	9992·5	9990·3	9989·4
	5.	15722·	15697·	15685·	15681·
	6.	23335·	23680·	23765·	23774·
	7.	165200·	167680·	167880·	167930·
Class C.	8.	84167·	83710·	83431·	83178·
	9.	656030·	653600·	651620·	650110·
	10.	4690000·	5008000·	5070000·	5080000·

per cent. In class B, more perfectly aged, the variations during the third month were only a few hundredths of one per cent; while in class A, if the resistances changed at all during the three months, the changes were so small as to be within the range of errors of observation.

Physical Laboratory of Columbia University,
April 18, 1900.

ART. XLI.—*On a new Meteorite from Oakley, Logan County, Kansas;* by H. L. PRESTON.

THE aerolite described in this paper was found fifteen miles southwest of Oakley, Logan County, Kansas, by Chas. Hicks, in the spring of 1895. He discovered it at a depth of about three feet below the surface, while ploughing on his farm.

Mr. Hicks states that it fell on Feb. 20th, 1894, about 11 P. M. and seemed to come from the N.E. It did not appear to burst before striking the earth, and, as stated above, was found by him the following spring. As to the date of fall of this meteorite Mr. Hicks is certainly mistaken, as will be shown later on. The mass passed from Mr. Hicks into the hands of Prof. G. H. Failyer of Manhattan, Kansas, from whom Prof. H. A. Ward of Chicago purchased it in December of 1899.

Its weight, when received by Prof. Ward, was 61 lbs. 10 oz. and was $7\frac{1}{2} \times 10 \times 12$ in. its greatest diameters. One side of the mass was covered entirely with the original crust, a large portion of it being of a dull black color, interspersed with numerous patches of yellowish brown rust spots, due to the oxidation of the iron. The opposite face showed the interior of the mass, a large flake, covering nearly three-quarters of the surface, having been broken off evidently at the time the mass struck the earth, as the surface was much oxidized and had the appearance of a very old break. Again, two-thirds of the edges were chipped, showing old fractures; while a large portion of the face showing crust, with several of the fractured surfaces on the edges, were coated with a very thick deposit of carbonate of lime. This could not have been deposited during the time that elapsed between the date of the fall, as given by Mr. Hicks, and the time it was found by him; on the contrary, it must have lain in the position where found a very long period of time in order to become thus thickly coated by the lime.

The larger surface of the mass showing crust is very smooth, entirely free from the customary pittings, except on one edge, of a thickness of $7\frac{1}{2}$ inches where large prominent and characteristic pittings are present.

On slicing the meteorite we find that the groundmass is compact, and grayish black in color, more or less spotted with much darker blotches or streaks, and abundantly flecked with bright iron grains. The largest of these observed was 6^{mm} in diameter; in the center of it is a small troilite nodule 1^{mm} in diameter. On the polished surfaces numerous grains of troilite are visible which form a strong contrast by their bronze-yellow color to the white nickeliferous iron.

The sections have also numerous fissures extending across their surfaces, following somewhat the rounded outline of the exterior of the sections. These fissures were probably caused by the contact with the earth's crust at the time of its fall.

By carefully powdering and repowdering 18 grams of this stone, and separating the iron from the silicates by a magnet, we found the ratio of the metallic part to the silicates as follows:

Metallic part	Fe	12·76
	Ni+Co	1·68
		14·44
Silicates		85·56
		100·00

An analysis of the metallic part by Mr. J. M. Davison of Reynolds Laboratory gave

Fe	89·16
Ni	10·84
	100·00

Specific gravity, 3·7.

Dr. Geo. P. Merrill of the U. S. National Museum, to whom I sent a few fragments of this stone, kindly made sections of some and examined them for me. "He found that the stone belongs to the chondritic olivine-enstatite type, though the chondritic structure to the unaided eye is somewhat obscure, well-defined, spherical chondrules being few and widely scattered. In general appearance it closely resembles the Pipe Creek, Bandera County, Texas, aerolite, but is of finer grain. Under the microscope it presents no features not common to aerolites of this class—olivine and enstatite chondrules imbedded in a very irregularly granular groundmass of the same materials, with numerous particles of metallic iron and iron sulphides. The chondrules present the characteristic barred (or grate) and fan-shaped structures, and are often themselves fragmental. The structure is on the whole very obscure, and more closely resembles that of Pipe Creek, as above mentioned, than any other of which we have slides. No silicate, other than olivine and enstatite, could be determined in the slides, but the solution obtained by digesting the powdered stone in dilute hydrochloric acid contained a trace of lime and alumina, suggesting the presence of a lime or a lime soda feldspar."

The stone would thus belong to the Meunier type 34, Erxlébénite.

Its nearest prominent geographical point being Oakley. It will be designated as the *Oakley meteorite* (Logan County, Kansas).

The eleven following meteorites have been reported from Kansas.

Tonganoxie	11·5	kilograms
Brenham (a number of pieces) over	900	"
Farmington (2 stones)	84	"
Ottawa	876	grams
Waconda	26	kilograms
Oakley	27·9	"
Ness County (17 stones)	10·9	"
Kansada	9·2	"
Jerome (2 stones)	31·4	"
Prairie Dog Creek	2·9	"
Long Island (a number of pieces)	534·6	"

The first on the list is a siderite, the second a siderolite, while the balance are aerolites. Of the nine aerolites but two, the Farmington and Ottawa, were seen to fall. Of the remaining seven we have no data whatever, even as to rumor, of the date of their fall; six of these, omitting the Waconda, are evidently remnants of a very old fall.

It seems that it is more than probable that five of these are representatives of the same fall. Starting with Ness County, of which seventeen stones have been found within a few miles to the S.E. and S.W. of Ness City, we have the Kansada found 17 miles N.W. of Ness City, the Jerome 39 miles N.W. of Ness City, the Prairie Dog Creek 88 miles N.N.W. of Ness City, and the Long Island 107 miles N.N.E. of Ness City.

We have thus a parallelogram 35 by 117 miles in diameter extending in a northeasterly direction, covering the area of these five finds.

They are all, as far as they have been cut, oxidized entirely throughout the mass, leaving the groundmass of a dark yellowish brown color, with but small patches of the original gray color of the silicates remaining. The crust in each case is much weathered and oxidized, and on portions of each find has been coated with varying thicknesses of the carbonate of lime.

The structure of each is chondritic, and macroscopically at least is very similar in other respects.

This statement cannot however be verified unless each of these five finds were analyzed by precisely the same method, and numerous sections from each made and studied under the microscope by the same petrologist.

It seems likely, therefore, that within this area we may expect that other stones bearing a close resemblance to these five will be found.

The remaining four aerolites are however entirely distinct in their character, and undoubtedly have no connection whatever with the unknown fall of the above five.

ART. XLII.—*Some Observations on Certain Well-Marked Stages in the Evolution of the Testudinate Humerus;* by G. R. WIELAND.

THE study of the morphology and development of an important skeletal part throughout an order must, as knowledge increases, throw much light on the evolution of the order itself. How far in the definite case here presented, the Testudinate humerus reflects the evolution of the *Testudinata* is a difficult question to answer even in general terms and as yet impossible to deal with finally. Nevertheless its present consideration, as based upon the fundamental principles of evolution, makes possible a clearer discernment of some valuable data.

Obviously if we select a specialized organ in a specialized group we may expect that the factors which have been potent in moulding it will have been on the one hand restricted in their action and on the other more strongly thrown into relief. Such an example is the Testudinate humerus, presenting also many advantages of study. For there is in the turtles to a degree scarcely approached in any other order a graduated change in habitat from dry deserts to the ocean, with varied feeding habits, as well as a wide distribution of both living and extinct forms in latitude and time.

. . . .

The two great groups of existing Testudinates, the land and the marine, the clawed and the flippered forms, each possess a characteristic humerus which can never be mistaken the one for the other. But if various intervening fossil types chiefly of Mesozoic age be considered, it at once becomes evident that there has been a steady and well-illustrated transition from whatever was the original form toward the humerus seen in the most highly specialized land turtles in the one direction, and toward that of the most highly specialized or *older* sea turtles in the other. That is, a series may be discerned with well-marked stages easily graduating into each other, at the one end of which stands the humeral form seen in various genera of the *Testudinidæ*, and at the other that of *Dermochelys*, which is either a very ancient, or else the most highly specialized marine turtle known.

Of these stages the attempt is here made to point out and describe six. In doing so it should perhaps be stated at the outset that while variations in humeral outline can scarcely be conceived of except as being chiefly adaptive in character, being so intimately connected with habitat, it will be seen that

quite constantly when dealing with well marked intervals in form there are accompanying generic or family variations. This is indeed so persistently the fact that *presence* of humeral differences must generally be regarded as of distinct diagnostic value, though absence of such may be simply non-determinative.

In the descriptions and notes which follow I shall term the most specialized land humerus as *parachelic*, and the generalized land and freshwater type as *chelic*. It will be seen that there is in general a corresponding humeral distinction between the more specialized and the more generalized land turtles.

Certain Mesozoic turtles regarded as transitional brackish or salt-water forms have intermediate humeri which may be described as *chelicoid* and *thalassoid*, the former resembling more nearly land, the latter oceanic outlines. Finally, the strictly oceanic and the ultra or specialized oceanic humeri will be respectively spoken of as *thalassic* and *parathalassic*.* Here also there is a certain corresponding general development.

The land forms (Parachelic and Chelic).

The *parachelic* humerus is in general that of short-clawed dry land tortoises, most of the genera of which are rather recent in geological time, and have probably been derived from longer clawed ancestors of more aquatic habit. This humerus is seen in such genera as *Testudo* and *Cinyxis*. Its strongly sigmoidal outline in the dorso-ventral plane with the proximal end upturned and the distal depressed, the reverse of the condition seen in the humerus of running mammals, at once strikes the eye. But with reference to other reptilia a most important feature is the closely proximal position of the radial crest or analogue of the deltoid crest. The ectepicondylar foramen or groove is distinctly ectal, diminutive, and situated well back from the distal end. There is never a very prominent ulnar crest or broad and rounded distal extremity as in *Chelydra*. Instead the distal articular surface forms a roller as in the *Lacertilia*, this being the most important distinguishing feature. (See fig. 12, introduced to show this point as well as the general correspondence of parts in the *Lacertilia* and the *Testudinata*, the same notation having been used for this purpose.)

It may be noted that there is correlated with this form of turtle humerus a tendency to form broad short heavy claws,

* As will be noted, the first three of these adjectives has been derived from the Greek χηλή, *chele*, hoof, claw,—that is humeri bearing clawed feet. It has been thought preferable to derive the second three from *Thalassa*, the sea,—a habitat in which claws are lost, rather than from πτέρυξ, *pteryx*, wing, used once by Nicander for the flipper of a turtle. Some might hold it better to derive the entire series from habitat.

the first step towards an ungulate type of foot. As seen in the accompanying figs. 1–4, the present is a plastic type of humerus which may be well marked in the case of forms only specifically distinct. The humerus of the senile genus *Miolania* Owen (15, 22) would probably fall within the *parachelic* series. *Testudo polyphemus*—with a complex as opposed to a simple carpus, and an innominate pelvis—affords a good example of the distal grooving and other modifications here emphasized.

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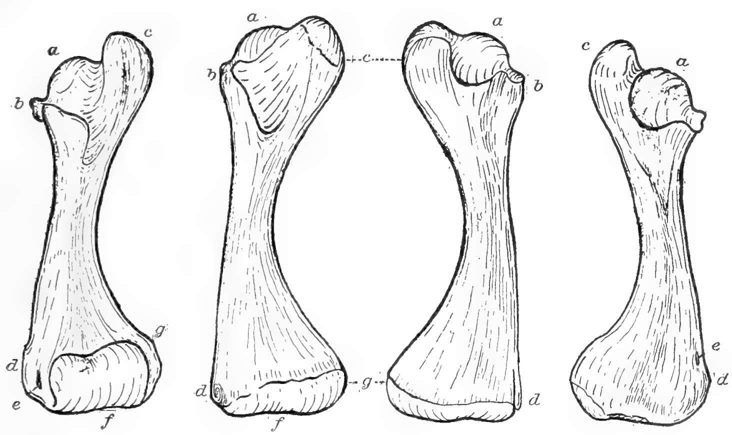


Parachelic humeri of Galapagos Islands tortoises. Outlined from Günther (9).*
FIGURES 1 and 4.—*Testudo elephantopus* Harlan,—ventral and dorsal view.
FIGURES 2 and 3.—*Testudo ephippium* Günther,†—ventral and dorsal view.
{ *a*, head; *b*, radial crest; *c*, ulnar crest; *d*, ectepicondyle; *e*, ectepicondylar foramen (or groove); *f*, ectocondyle; *g*, entocondyle.

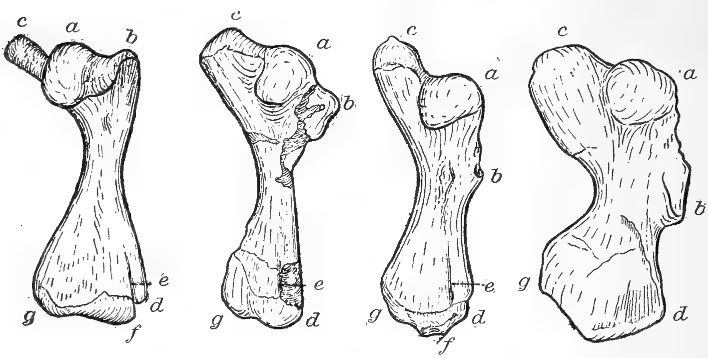
The Chelic humerus.—The fundamental difference between the second or *chelic* type of humerus and the preceding consists in the straightening of the distal extremity into a simple rounded end bearing the articular cartilage, without development into a grooved articular surface. The ulnar crest may be more prominent, and the ectepicondylar foramen oftener seen as a groove more distal in position, but always near the outer edge.

Most distinctly clawed *Testudinates* have this form of humerus, and as these range from land and freshwater to web-toed and partly brackish water species, distinct variations, such as increase or decrease in the angle between and size of the ulnar and radial crests, may be expected, and are present.

* Nos. in parentheses refer to list of references page 423.

† Dr. Baur has proposed to call this tortoise *Testudo Abingdonii* (3), but Rothschild (16) and Günther (11) have shown that *T. ephippium* is to be retained.

Though the uniformity with which this humerus ranges through many genera of the *Cryptodira*, *Pleurodira*, and *Trionychia*, render it as yet of little value to the paleontologist, excepting the *Chelydran* variation here included, although somewhat aberrant and suggestive of natatorial types. Examples of *chelic* humeri are seen in the genera *Emys*, *Chelopus*, *Trionyx*, *Podocnemis*, *Chelydra*, *Chelys*, and others.



Dorsal views of right humeri showing descent of radial process as noted by Dollo (8). Lettering as in figure 1.

FIGURE 5.—*Chelydra serpentina.*
FIGURE 6.—*Lytoloma crassicostatum* Owen (Lower Landenien (Lower Eocene) of Erquellines).
FIGURE 7.—*Chelone mydas* L.
FIGURE 8.—*Protostega gigas* Cope, × about $\frac{1}{7}$. (Niobrara Cretaceous.)
FIGURES 5–7 are outlined from Dollo (8), figure 8 from Cope (6).—Figure 5 is regarded as *Chelic*, 6 *Thalassoid*, and 7 and 8 as *Thalassic*.

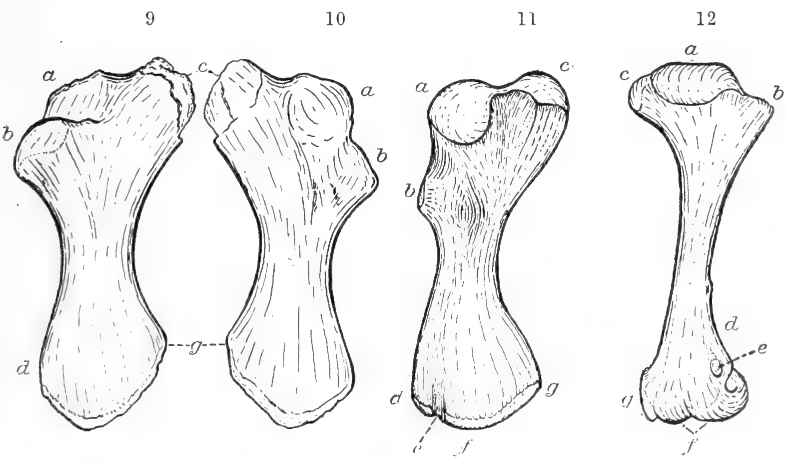
The transitional Water-types of the Mesozoic.

The Chelicoid Form.—General osteological characters in addition to position in time have led to the belief that the straighter shafts noticed in certain Jurassic turtles such as *Acichelys*, are those of primitive oceanic Chelonia. As these humeri yet bear a distinct resemblance to the land forms they may be described as *chelicoid*. They are characterized by an imperfectly developed head, a straightening of the shaft and small ulnar and radial processes, the latter being placed on the level of the head. Examples are seen in the *Acichelyidæ* (14) of the Wealden and Kimmeridge; also in the more chelic humerus of *Acichelys* (Eurysternum) *Wagleri* (22), which has the lateral proximal crests small, but the articular head relatively large with some straightening of the shaft.

It is to be noted that these intermediate forms are the most difficult to place, and that between them and the following

quite distinct early marine, or *thalassoid* humerus there is no very well defined boundary. However, if all the forms were known there would be no hiatus at any point, especially since it would then be possible to determine offshoots from the main line of descent.

The Thalassoid Humerus.—The second transitional form includes humeri of turtles which had probably become wholly marine in habit, but retained certain features of their semi-marine ancestors with *chelicoid* humeri. The conversion into the generalized marine form is however completed by the variations seen in this humerus. The drop of the radial crest so strongly marked in succeeding marine turtles begins, while the angle between this crest and the ulnar crest tends to disappear, the latter becoming very prominent in an ecto-enteral plane. Cf. figs. 6, 9, and 10, also 5–8 in text.



Thalassoid and thalassic turtle humeri (with lizard humerus compared with figures 1–4). Lettering as in figure 1.

FIGURES 9 and 10.—*Neptunochelys* (Protostega) *tuberosa*, $\times \frac{1}{5}$. From Cretaceous near Columbus, Mississippi, outlined from Leidy (12). See note p. 418.
FIGURE 11.—*Thalassochelys caretta.* Left outer view.
FIGURE 12.—*Heloderma suspectum* Cope. Right dorsal view.

The humerus of *Lytoloma*, which has been made the subject of a suggestive paper by Dollo (8), may be cited. He holds this form to be essentially "*chelydroid*," a view which is in the main concurred in here. For convenience in the present classification, the term *thalassoid* may as well be used, the resemblance to the humerus of the *Cheloniidæ* being fully as strong. It should be borne in mind that the *chelicoid* humeri of the *Acichelyidæ* intervene, so far as may now be judged,

between such forms as *Lytoloma* and *Toxochelys* on the marine side, and the humerus of *Chelydra*, a *chelic* or land form modified as has been previously noted, in the direction of natatorial types. It is of course possible that the flippered *Cryptodira* represent several lines of descent from land forms, each having distinct, but in the main, parallel characters.

Another very distinct *thalassoid* form which may well be mentioned here is the "turtle-like humerus" from the Cretaceous near Columbus, Mississippi, figured by Leidy and at first referred by him to the *Mosasauria* (12).* As will be seen on comparing figs. 6, 9, and 10, this fossil presents decided approximations to *Lytoloma*, there being however distally more suggestion of distinctly oceanic types.

The humerus of *Toxochelys latiremis* figured by Case (4) is a suggestive *thalassoid* form characteristic of the older *Cheloniidæ* and closely nearing typical oceanic outlines.

With regard to these two transitional forms, the *chelicoid* and *thalassoid*, it may be said that they fairly bridge over the fundamental differences between the humeri of the existing marine and land *Testudinata*. The number of complete skeletons is as yet so meager that the facts can only be presented in a general way.

Turtle humeri of intermediate type are common in the Cretaceous of New Jersey, but there is a dearth of knowledge concerning the forms to which they belong, the collections consisting as yet mainly in hopeless fragments gathered from the surface by untrained collectors, whose efforts usually result in the destruction of the clues to completer specimens.

The Typical Oceanic, or Thalassic and Parathalassic Humeri.

The *thalassic*, or form of humerus seen in the living *Cheloniidæ*, is a widely distributed one and may be considered as the true or generalized ocean type. Variations of this form are seen in the *Protostegidæ* of Cope (6), and the *Desmatochelyidæ* of Williston (19, 20). Cf. figs. 13, 17, 19, and 22 in the present text.

* Leidy has explained in an interesting manner how at a time when the limbs of the *Mosasaurs* were yet unknown, both Cope and himself, as well as Agassiz, had mistakenly concurred in a belief in the Mosasauran character of this fossil (13). Cope was, however, the first to refer to its Testudinate nature under the name *Protostega tuberosa* (6). While the type specimen has not been seen by the writer, there is no suggestion that this humerus is not Testudinate and natatorial in character. Baur has said that it cannot belong to the *Cheloniidæ* (2). Neither can it belong to Cope's *Protostegidæ*, nor to Agassiz's genus *Atlantochelys* as finally proposed by Leidy (13). Cf. figs. 14–16 and 9 and 10 in text. This humerus lacks at the present time a generic name. Necessarily retaining Cope's species, I shall call the turtle to which it belongs *Neptunochelys tuberosa*.

As compared with the preceding or *thalassoid* form the chief variation is seen in the distal retreat of the radial process. No distinct approximations to any of the land forms remain. The entire development is in an ecto-enteral plane. The strong dorso-ventral sigmoid curve, and sharp angle between the radial and ulnar crests as seen in the *parachelic* and *chelic* forms has disappeared.

This type scarcely shows as much constancy of form as the generalized land humerus, but is yet sufficiently uniform to raise any fairly well marked differences to generic value.

Variations of this humerus may very well be illustrated by mentioning certain fossil forms. Of primary interest is the

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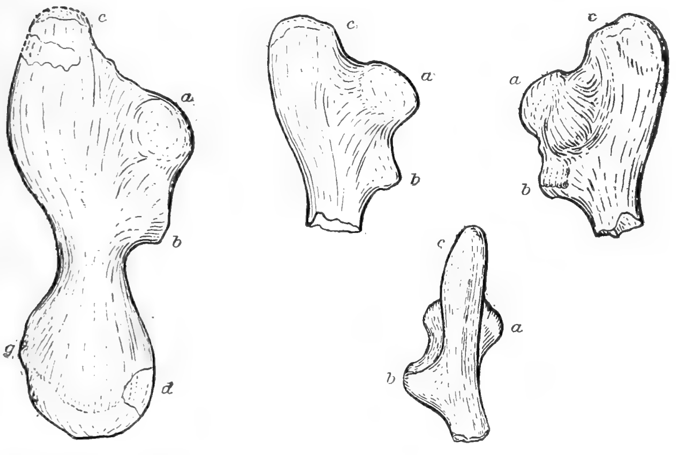


Fossil *Thalassic* humeri of nearly related genera derived more directly from the *thalassoid* form. Cf. figs. 6, 9 and 10.

FIGURE 13.—*Desmatochelys Lowii* Williston, $\frac{2}{9}$ natural size. From Fort Benton Cretaceous. Outlined from Williston (20).

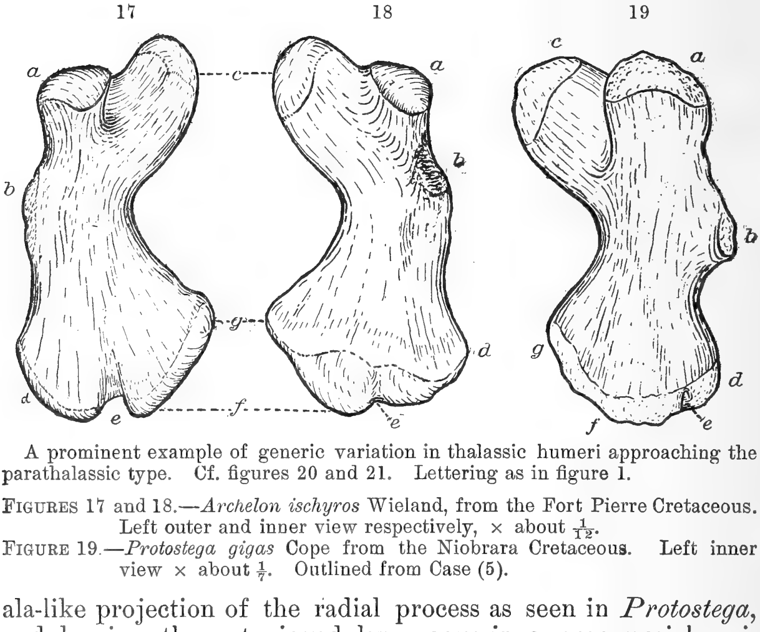
FIGURES 14–16.—*Atlantochelys Mortonii* Agassiz, × about $\frac{1}{9}$. From the Green sand of Burlington County, New Jersey. Outlined from Leidy (12).

historic *Atlantochelys Mortonii* Agassiz described in 1849 (1). Subsequently Leidy referred this fossil humerus, together with that of *Neptunochelys* (Protostega) *tuberosa* mentioned above, to the *Mosasauria* (12). Later Cope referred it to *Protostega* (6). Finally it was validly rehabilitated by Leidy (13). The strongest resemblance of this important form, not before pointed out I believe, is to *Desmatochelys Lowii* Williston (20, 21), the main skeletal characters of which are fortunately known. The resemblance is sufficiently close to suggest allied

genera. Cf. figs. 13 and 14–16. A complete skeleton of *Atlantochelys* should be diligently sought for.

The significance of such variations as may be present in *thalassic* humeri is shown by the well known *Protostega gigas* Cope from the Niobrara Cretaceous of Kansas, and the more recently discovered *Archelon ischyros* (mihi, 17–19) from the overlying Fort Pierre formation of South Dakota. Both these humeri are illustrated in figs. 8 and 17–19 in text.

While the head and ulnar crest are quite similar in both forms, in *A. ischyros* there is a minor development of the radial crest, with a more ental position of the deep ectepicondylar groove. Or conversely it may be said that there is a major development of the ectepicondylar region, obscuring the



A prominent example of generic variation in thalassic humeri approaching the parathalassic type. Cf. figures 20 and 21. Lettering as in figure 1.

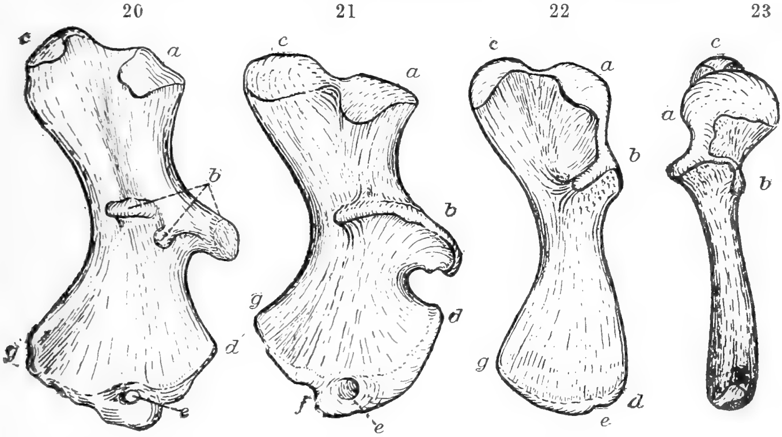
FIGURES 17 and 18.—*Archelon ischyros* Wieland, from the Fort Pierre Cretaceous. Left outer and inner view respectively, × about $\frac{1}{12}$.

FIGURE 19.—*Protostega gigas* Cope from the Niobrara Cretaceous. Left inner view × about $\frac{1}{7}$. Outlined from Case (5).

ala-like projection of the radial process as seen in *Protostega*, and leaving the ectepicondylar groove in a more mesial position. Such a difference is fundamental in the thalassan forms, and the probability that it will be accompanied by marked cranial and other variations is very great. This instance is all the more important because of the direct descent of *A. ischyra* from *P. gigas* (19).

The Parathalassic Humerus.—The final humeral type to be mentioned is the *parathalassic* seen only in a single living example, the most aberrant of sea turtles, *Dermochelys*. In this humerus dorso-ventral curvature of the shaft has wholly

disappeared, and there is an extreme retreat of the radial process. The ectepicondylar groove of the *thalassic* humerus is here deepened into a foramen, it being wholly probable that this change has been correlated with the retreat of the radial crest in this and preceding forms. It will be noticed that the humeri of *Protostega* and *Archelon* are not placed in the same class with this form. There are only vague resemblances with great differences. The peculiarities of the *parathalassic* form may be accentuated by mentioning a most interesting Pliocene example seen in *Psephophorus scaldi*, a turtle which like *Dermochelys* is provided with an external dorsal and ventral bony armor (14). In figs. 20 and 21 it will be noted that anteriorly the radial process of *Psephophorus* is very prominent, while



Views of left humeri showing intermediate or *thalassic* position of the radial crest and ectepicondylar foramen (groove) in figures 22 and 23, and the extreme or *parathalassic* position in figures 20 and 21. Letters as in figure 1.

FIGURE 20.—*Psephophorus scaldi.* From Pliocene of Belgium. Left ventral view × about $\frac{1}{7}$. Outlined from Dollo.

FIGURE 21.—*Dermochelys coriacea.* Recent. Left ventral view × $\frac{1}{8}$.

FIGURES 22 and 23.—*Thalassochelys caretta.* Left ventral and ectal views.

its ventral extension is either disappearing or lacks the strong development seen in *Dermochelys*, only two isolated areas for ligamental attachment being present. Chelonian paleontology awaits complete knowledge of no more interesting forms than the several less known species of *Psephophorus*.

Conclusion.

Whenever it becomes possible to compare an entire series of *Testudinate* humeri and tabulate the results, definite affirmation or negation of causes of development and means of adaptation may be expected. At present only general conclusions can be reached, and these be but briefly stated.

As a modification of mechanical change the instance of responsive variation afforded by the peculiar curvature of the humerus to conform to the presence of the carapace and plastron is impressive. The external armature once developed, the humerus seems to have continuously accommodated itself to it during all the secondary changes subsequently undergone.

Much interest too centers in the transitional forms. That the gap between the *chelic* and *thalassic* humeri must necessarily have been bridged over by primitive straighter shafts cannot be directly affirmed, however strong such an inference at present. For other swimming reptiles with straight humeri scarcely furnish an explanatory analogy. Such have lithe instead of rigid bodies and are provided either with a caudal fin or a powerful swimming tail. There are, however, salient facts bearing on this point.

Those turtles which inhabit dry and especially rocky localities present the most specialized land humerus, while species of intermediate habits like *Chelopus* are marked by the generalized type of land humerus. In passing however from such to the more and more aquatic turtles there is an increasing freedom of leg movement. Footings, or the *fulcra of locomotion*, as used by the animal become more and more equally distributed about the body and undoubtedly furnish a sufficient explanation for humeral straightening in the transitional forms, and the fundamental difference in curvature between the humeri of the existing slow-moving land and swift-moving marine turtles.

Once having entered salt water, a new course of evolution began. The early transitional Testudinates so far as the fossil record indicates were mainly of inconspicuous size. They were yet to undergo development into large and powerful more or less predatory forms invading the high seas. That such an evolution required a constantly increasing differentiation in humeral outline and musculature, is evident. Small creatures of varied feeding habits living in quiet waters, taken together with the fierce turtles of the Cretaceous seas and the huge predaceous *Dermochelys* sweeping the ocean and baffling with its currents and storms, suggest the utmost variation in humeral impacts, stresses, and strains.

The only basis for variant or perfecting leg power is a variant or perfecting musculature, and the only support of this correlated skeletal modification. The nature as well as the extent of such modification in the *Testudinata* will be still better understood after a comparative study of the humeral myology of the order. It is quite obvious at least that the humerus furnishes as readily distinguishable and as important characters as the carpus.

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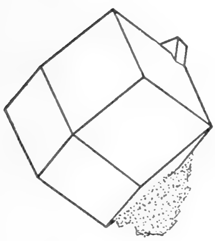
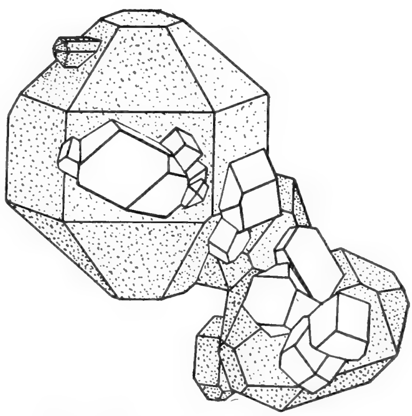
ART. XLIII.—*On the Chemical Composition of Sulphohalite;* by S. L. PENFIELD.

THE rare species sulphohalite was first described in 1888 by W. E. Hidden and J. B. Mackintosh* as a mineral of unusual composition, a double sulphate and chloride of sodium corresponding to the formula $3Na_2SO_4.2NaCl$. It was found associated with the then recently discovered hanksite, at the famous Borax Lake locality, San Bernardino County, California. It crystallizes in rhombic dodecahedrons, belonging to the isometric system and measuring at times over 30^{mm} in diameter. According to information received from Mr. Hidden, only a few specimens of the mineral were found. Two of these are in the collection of Mr. C. S. Bement of

1



2



Philadelphia, and one in the British Museum, while the type specimen from which material for the original analysis by Mackintosh was obtained, was retained by Mr. Hidden. This latter specimen has been generously presented to the writer, with the understanding that part of it should be used for a new analysis and the remainder deposited in the Brush Collection of the Sheffield Scientific School.

Figs. 1 and 2 represent the two specimens in the Bement Collection, natural size. The one represented by fig. 1 is a rhombic dodecahedron of almost ideal development, slightly yellowish in its tone of color, and nearly transparent. A very little gangue, chiefly hanksite, and a few small crystals of sulphohalite are the only things attached to this superb crystal,

* This Journal, III, vol. xxxvi, p. 463.

and the specimen can be so held that only small portions of these are visible. The second specimen, fig. 2, consists of a group of three large and a few small hanksite crystals upon which a number of sulphohalite dodecahedrons have grown. The figure is merely a sketch, hence it is not to be considered as an exact crystal drawing; however, pains have been taken to represent the crystals in their proper size and proportions, and, for the sake of distinctness, the hanksite crystals have been stippled. All of the sulphohalite crystals are distributed on one side of this specimen only.

The writer's attention was directed to the desirability of reinvestigating this species by the following circumstances: In January of the previous year, a letter was received from Prof. A. de Schulten of the University of Helsingfors, Finland, stating that he had repeatedly attempted to reproduce sulphohalite artificially, but always obtained sodium chloride and sodium sulphate, crystallizing respectively as halite and thenardite. As he was unable to obtain specimens of sulphohalite from mineral dealers, he appealed to the writer to make if possible a new analysis of the mineral, and, if this should conform to the composition as given by Mackintosh, he expressed his determination to proceed with his endeavors to make the mineral by artificial means. A short time previous, in an article entitled "*Die Bildungsverhältnisse der oceanischen Salzablagerungen*" by J. H. van't Hoff and A. P. Saunders,* reviewed in this Journal,† the probable non-existence of sulphohalite had been set forth. This decision was based chiefly upon the failure of these investigators to obtain by artificial means a double sulphate and chloride of sodium corresponding to the composition as given by Mackintosh, their experiments, like those of de Schulten, yielding crystals of halite and thenardite. They furthermore endeavored to secure sulphohalite specimens from dealers, and two that were sent to them proved upon examination to be simply halite. Lastly, a request came from Mr. Hidden that the writer should make a new analysis of sulphohalite, for the purpose of definitely establishing the identity of the species and its chemical composition, and the request was accompanied by the gift of the precious material.

The material submitted for examination was part of a rhombic dodecahedron which must have originally measured about 30^{mm} in diameter. To it were attached several small prismatic crystals of hanksite. The sulphohalite material was clear, transparent, and homogeneous, and when tested with the polar-

* Sitzungsberichte der K. Akad., Berlin, 1898, vol. i, p. 387.
† Vol. iv, p. 511, 1898.

izing microscope it was found to be isotropic. The fracture is small conchoidal, and the absence of any distinct cleavage is noticeable, thus distinguishing it from halite. The material for analysis, after being carefully selected, was crushed and sifted to a nearly uniform grain, and separated by means of methylen iodide diluted with benzol. Nearly all of the material ranged in specific gravity within the narrow limits 2·493 and 2·506. The average of these determinations, 2·500, may be taken as the correct specific gravity, which is close to that given by Hidden and Mackintosh, 2·489. The material thus separated, when tested with acid, gave no effervescence, thus indicating perfect separation from hanksite. A few fragments, mostly hanksite, which were heavier than the product separated for analysis, effervesced with acids, hence failure to make a complete separation from hanksite undoubtedly accounted for the small percentage of Na_2CO_3 recorded in Mackintosh's analysis.

After completing the quantitative determinations of Cl, SO_3 and Na_2O, the constituents required by the formula as given by Mackintosh, a deficiency was noted in the analysis, which for a time proved very perplexing, but led finally to the discovery of another and rather unexpected constituent, namely fluorine. In recording the analysis, sufficient sodium has been taken to combine with the chlorine and fluorine to form the molecules NaCl and NaF, respectively, while the remainder of the sodium is given as oxide.

The results of the analysis are as follows:

		Ratio		Calculated for $2Na_2SO_4.NaCl.NaF$.		Results of Mackintosh.
SO_3	41·79	·522	2·00	41·61		42·48
Na_2O	32·37	·522	2·00	32·25		
K_2O	0·10					
Na	11·60			11·97		
Cl	9·10	·256	0·98	9·23		13·12
F	4·71	·248	0·95	4·94		
Ign	0·15				Na_2CO_3	1·77
	99·82			100·00		

The ratio of SO_3 : Na_2O : Cl : F approximates closely to 2 : 2 : 1 : 1, and since the sodium (Na) recorded is just sufficient to unite with the chlorine and fluorine, the formula of sulphohalite becomes $2Na_2SO_4.NaCl.NaF$. Fluorine was weighed as calcium fluoride, and the purity of the product was proved by converting it into calcium sulphate. It is interesting to note the association of this mineral, having three acid constituents, with hanksite, which also has three acid constituents,

its composition, according to the investigation of Pratt,* being $9Na_2SO_4.2Na_2CO_3.KCl$. Although the presence of fluorine in sulphohalite was wholly unexpected and seemed at first surprising, the occurrence of that constituent in some mineral from the Borax Lake locality is not to be wondered at. This important deposit of borax has been formed undoubtedly from fumerole or solfataric action, and it is well established that volcanic gases frequently give rise to fluorine as well as to boron, chlorine, and sulphuric acid compounds.

Probably the name sulphohalite would not have been given to this mineral had its composition been correctly determined by Mackintosh; however, one would scarcely be justified at the present time in assigning a new name to the compound. To a certain extent van't Hoff and Saunders were correct in calling attention to the probable non-existence of the species, for, although the mineral in name and substance had an existence, a double salt of the composition $3Na_2SO_4.2NaCl$ ascribed to sulphohalite is not known, and, apparently, cannot be made by artificial means.

It is needless to speculate as to how Mackintosh, who was an experienced and careful worker, made an erroneous analysis. His determination of SO_3 was nearly correct, while that of chlorine was four per cent too high. In one respect he certainly made a decided mistake, namely in not completing his analysis by determining the amount of sodium, for, had he done so, he probably would have noted a deficiency and this naturally would have led to the discovery of the missing constituent.

Mineralogists certainly are indebted to Mr. Hidden for the discovery of this exceptionally beautiful and interesting mineral, while his eagerness to have the species correctly investigated, together with his generosity in supplying the necessary material have enabled the writer to carry on this investigation. Thanks also are due to Mr. Bement for the loan of his valuable specimens.

* This Journal, IV, vol. ii, p. 133, 1896.

Sheffield Laboratory of Mineralogy and Petrography,
Yale University, New Haven, March, 1900.

ART. XLIV.—*Some Phases of the Dakota Cretaceous in Nebraska;* by CHARLES NEWTON GOULD.

[A paper read before the Nebraska Academy of Science, Dec. 1, 1899.]

NEBRASKA is the home of the Dakota Sandstone. It was along the bluffs of the Missouri River opposite Sioux City that Meek and Hayden first noticed the ledges of dark brown and red sandstone which formed the No. 1 of their now classic Cretaceous section of the Missouri River. This was as early as 1853. The *name* Dakota is not from the State, but from the town of Dakota, the county seat of Dakota County, the northeastern county in the State. The first fossil leaves collected by Meek and Hayden were from Nebraska. These were dicotyledons, the first of the magnificent series, comprising perhaps the most luxuriant fossil flora in the world. It was to Nebraska that the noted French geologists Capellini and Marcou came in 1863 when they made their celebrated collection at Tekamah and Black Bird Hill. This collection, figured and described by Oswald Heer, the noted Swiss paleobotanist, forms the basis of all later Dakota paleobotanic literature. It was to Nebraska that Leo Lesquereux, "the Nestor of American paleobotanists," came when he first studied the Dakota in the field. The type sections and many of the type species of fossil leaves from the Dakota sandstone are Nebraska's.

Nevertheless, judged from the standpoint of exposures alone the Dakota in Nebraska is comparatively insignificant. The heavy mantle of Glacial drift and loess which covers the eastern third of the State in most places completely conceals the subjacent formations, including the Dakota. It is only in comparatively small areas where erosion has removed the post-Cretaceous deposits that the Dakota may be seen. Probably the entire area of visible Dakota would not cover a single county the size of Lancaster, while the country underlaid by this group comprises more than a dozen counties in the east-central part of the State.

The largest single area is south of the Little Blue River, near Endicott and Fairbury in Jefferson County, just beyond the line of Glacial drift. The second largest is probably Iron Mountain, a few miles southeast of Beatrice. With a few minor exceptions the remaining outcrops are isolated points along the bluffs of Salt Creek, the Platte River below Fremont, and the Missouri River from Omaha to Ponca. The eastern limit so far as known is near the towns of Odell, Holmesville, Bennett and Plattsmouth, and the western limit near Fairbury, Milford, Seward, Fremont and Ponca. The

area of outcrops is about two hundred and fifty miles long and on an average thirty-five miles wide, extending crescent-like through Fairbury, Beatrice, Lincoln, Louisville, Blair, Tekamah, Decatur and Ponca. Dakota City, from which the group was named, is ten or more miles from the nearest bluff.

For the most part the Dakota in Nebraska consists of rather soft reddish brown or gray sandstone, usually in ledges or lenses, imbedded between strata of more or less arenaceous clay shales. These shales greatly predominate, perhaps in most places comprising two-thirds to three-fourths of the entire thickness of the formation. In color they are whitish, or bluish with many strata of red or brown, caused, as in the case of the sandstone, by the presence of iron. The reason that the shales are usually so seldom noticed may be accounted for by the fact that they weather very readily and their outcrops are generally occupied by covered slopes. On the other hand, the relatively harder sandstone forms the conspicuous bluffs, mesas and escarpments which give to the Dakota region its characteristic contour.

The clays and shales form an important economic phase of the Dakota. They have been excavated at several localities in the State, furnishing an excellent quality of brick, tile, etc. Endicott, Beatrice, Lincoln and Louisville in Nebraska and Sioux City and Sargeant's Bluff in Iowa are points from which clay for this purpose has been obtained. As the supply is practically inexhaustible and the quality exceptionally good, the Dakota clays promise to become an important economic factor.

The sandstone is used for building purposes in a number of localities in the State. The entire line of outcrops from Sioux City to Kansas may be traced by the brown sandstone foundations of houses and outbuildings. As a general rule, however, large buildings are not constructed of the Dakota sandstone, although at Endicott, Beatrice, Louisville and other places these may be found. The reasons for this are twofold; first, the Permian or Carboniferous limestones, which are exceptionally fine building material, are nowhere far distant; and second, the Dakota itself is not, as a usual thing, a first-class stone for building purposes. Representing all degrees of hardness from loose sand scarcely cemented together to the hard brittle ironstone concretions, it is usually too soft to withstand erosion or too hard to be dressed. Ledges yielding suitable building stone are comparatively rare.

At least one locality in the State furnishes a ledge of Dakota which is quite unique. About five miles northwest of Fairbury, Nebraska, on Whiskey Run, near the home of Mr. Oberhelmen, is a ledge some three feet thick of an extremely

hard, fine-grained, quartzitic sandstone. The color is light gray becoming reddish on exposure. This quartzite contains an abundant dicotyledonous flora, also some conifers, probably Sequoia. The ledge is quarried and makes an excellent building stone, but it is in bad repute among local stone masons, because of the fact that it is too hard to be dressed. It differs from anything seen elsewhere in the State except somewhat similar ledges found near the old mission on the Omaha Reservation and along the bluffs to the north, although quartzite bowlders similar in character are found in Saline and McPherson counties, Kansas.

Another feature of the Dakota in Nebraska may be observed along the Platte River near Louisville and Cedar Creek. The lowest formations here exposed are the Upper Carboniferous limestones and shales. Upon these the Dakota rests unconformably and the whole is covered as elsewhere by the loess and drift. The pre-Cretaceous erosion was not only very considerable but also very irregular. The hills of the old Carboniferous rocks upon which the Dakota was deposited were probably higher and the hollows deeper than those in the same region to-day. It was in one of these eroded hollows, probably the bed of an ancient Dakota river, that there was deposited an immense amount of coarse sand and gravel. This forms the gravel pits near Cedar Creek and Springfield.

In the gravel bed a mile west of Cedar Creek a typical exposure may be seen. A spur from the B. & M. railroad runs along the base of the hill up to the quarry. The lower fifteen or twenty feet consist of an extremely hard conglomerate usually cross-bedded. The pebbles composing this conglomerate are smooth, water-worn, usually white or yellowish quartz. They vary from the size of a walnut to a very fine sand. This part of the ledge is not quarried, but forms the floor of the portion above, which is removed.

The upper part consists of similar material with the important difference that it is much more loosely cemented. The pebbles are usually somewhat smaller and there are some layers of rather fine sand and occasionally the characteristic ironstone concretions which are always present in the Dakota. This second member is thirty to forty feet thick and is excavated for nearly a quarter of a mile along the side of the hill. In many places it is so loosely cemented that it is removed with a team and scraper, not even a plow being necessary to remove the material. The gravel is used for railroad ballast and the conglomerate, known locally by the expressive name of "peanut rock," is employed as riprap and filling material for bridges.

A number of fragments of fossil wood, including a limb some three feet in length, were found in the quarry, but no leaves have so far been discovered.

If our theory that these gravel beds represent an ancient river bed be correct, it is not difficult to understand that the conditions would have been favorable for the preservation of wood, and not for that of leaves, the latter requiring still-water lakes and lagoons for perfect preservation. Besides, the principle first enunciated by Leo Lesquereux, that conditions which preserved leaves rarely preserve wood, and vice versa, has almost become an axiom in phytopaleontology.

Above the gravel and sand is the line of Drift bowlders surmounted by the characteristic loess. This gravel bed has been described as belonging to the Glacial age. It is incomprehensible that any one, who knew anything of the geology of the State of Nebraska and who had given the locality five minutes consideration, could place it elsewhere than in the Dakota.

Perhaps the most important phase of the Dakota, from an economic standpoint, is the water supply. This formation is characteristically a water-bearer. From Oklahoma to Minnesota along the entire line of outcrops are thousands of springs of soft water. This is especially fortunate in view of the fact that the region of the sandstone is particularly adapted to grazing. It almost never occurs that a pasture in the Dakota country is without a spring, and more often half a dozen will be found on a quarter section. Often these are of sufficient strength to supply running streams. If this is not the case, the stockmen usually pipe the water into tanks in the field or feed lot. In not a few instances the water from a Dakota spring is piped half a mile or more, through the house, and into the barn lot, furnishing an inexhaustible supply for all purposes. Some of the most important of these springs in Nebraska are Case's and Price's springs near Endicott; Robinson's spring, four miles southeast of Beatrice, and the hundreds along the bluffs of the Missouri River from Omaha to Ponca. These may be seen everywhere along the celebrated bench road at the foot of the bluffs. Golden spring, between Tekamah and Decatur, runs a stream half as large as a man's body, and numerous others are nearly as large.

A formation which yields such springs could scarcely fail to furnish good wells, and such is the case with the Dakota. Wells begun in the superjacent strata usually find an abundant supply of water when they reach the sandstone. The problem of water supply of eastern Nebraska is easy of solution, if one has as a key, a knowledge of the Dakota sandstone.

The origin of Dakota water is a mooted question. Some authorities look for the source of supply in the Dakota outcrops along the eastern slope of the Rocky Mountains. They would consider the water artesian, and argue that deep wells over the central part of the State should tap this supply and furnish artesian water. This theory seems quite tenable, but in practice it remains to be proven. That it will not account for all Dakota springs is demonstrated by the fact that in several instances some of the best springs issue from isolated buttes, cut off by erosion from the main body of the Dakota. It seems more probable that much of the water supply comes from local rainfall, although until the artesian theory is either proven or disproven we may well continue to look farther away for a part of the supply.

The most interesting point connected with the Dakota, from the standpoint of pure science, is of course the fossil leaves. Few formations in the world have yielded so many species. Of the nearly five hundred forms known to exist, Nebraska furnishes a large per cent. Numerous localities are known to yield leaves. The best collecting ground so far discovered in Nebraska is five miles south of Endicott, Jefferson County, and near Decatur, Burt County. Very little systematic work has been done on these leaves for a number of years, but at the present time the collections of the past summer are being studied in the department of Geology in the University of Nebraska, and it is expected that a detailed report on the subject will shortly be published.

ART. XLV.—*The Geothermal Gradient in Michigan;* by ALFRED C. LANE.

1. A WELL has recently been sunk in Bay City to the depth of 3,508 feet. I have had various tests made, and a man watching it most of the time. The temperature tests were made with Green's self-registering maximum thermometers by Prof. C. A. Davis, of Alma College, resulting as follows:

Depth.	Reading °F.	Time Exposed.	No. of instrument.	Calculated Temperature.
3,455	97°	8 hours	5688	97·3°
2,934	90·1° 90·2°	1 hour	5688 5690	89·48°
2,282	77·° 77·°	30 minutes	5688 5690	79·7°
1,793	71·°	50 minutes	4708	72·37
1,304	65·°	1 hour	4708	65·03

It is to be regretted that all the work could not be done with one thermometer, but two were lost by accident. Still we have some valuable results.

The average mean temperature of Bay City* is about 45·5° and in the early salt well at Saginaw, only ten miles away, a strong flow of slightly saline water had the temperature of 47° at a depth of 102 feet, at 293 feet the temperature of the flow was 50°, at 531 feet 51°, at 617 feet 54°. These latter data agree in pointing to a mean surface temperature of 45·5° with an error of not more than half a degree. We obtain then, for the mean gradient to 3,455 feet, 1° F. in 67·07 feet or very nearly 3° F. in 200 feet, or 1° C. in 36·8 meters. We can very nearly express the gradient by the formula $0·015(d-102) = t-47$, (d) being the depth in feet from the surface and (t) the temperature Fahrenheit, and from this formula the last column of the table is calculated.

It will be noticed that while the agreement with the formula is close at 3,455 and 1,304 feet, at 2,282 and 1,793 feet the observed values are low, which result seems to be a sign that at those depths the thermometers were not left down long enough.

Let us compare with other points. The temperature of the Midland brine from a depth of 1,205 feet has a temperature of 62·5° F., which agrees exactly with a gradient of 1° F. in 67 feet from a mean surface temperature of 44·5° F., which is that of the place.

The Alma well temperature of 98° at 2,863 feet gives a

* See Water Supply paper No. 30, U. S. G. S., Fig. 4.

higher gradient, but the chances are it was taken with a thermometer not reliable, and perhaps before the heat of drilling had been dissipated. In case of the Bay City well the well had been idle from January 18 to April 13, 1900, the date of the tests, and had gradually filled with a strong heavy brine which was slowly leaking in from the bottom measures when they stopped.

At Alpena flowing wells drawing their supplies, probably, mainly at 698 to 711 feet, and certainly below 588 feet, have a temperature of 53°. The mean surface temperature is about 42°, and the gradient about the same.

At Frankfort two wells with strong flows giving off H_2S freely, the one 2,200, the other 1,800 feet deep, have temperatures of 56° and 54° F. respectively, but the water is said to come in about 800 feet down. There are reasons for believing that the water comes from the Corniferous, and it is pretty certainly not from the drift and must come more than 570 feet down. The mean annual temperature is about 44°, so that the gradient is a little less than heretofore, probably about 1° in 80 feet.

The gradient thus indicated is much lower than that found by Darton, but quite comparable with those found by W. Hallock in the Wheeling boring in similar strata.

2. If, however, we turn to the Upper Peninsula we have a region notorious for its low thermal gradient. I will not try to summarize all the data collected by Wheeler, Agassiz and others, but merely say that around Calumet from a mean surface temperature of 40° F. the temperature rises to about 84° F. at 4,400 feet, almost exactly 1° F. in 100 feet.* This gradient is probably not confined to the Copper Country. Some not very accurate tests which I made in the Vulcan Mine on the Menominee range (with a cheap thermometer, afterward compared with a better) gave 56° at a depth of 1,210 feet. A heavy flow of water (as P. Larrsen, C. E., informed me) 80 to 90 feet below surface was at 44° F. This gives a gradient of 1° in 94 feet.

3. The causes of the low gradient of Keweenaw Point have been discussed, and various explanations of variation of gradient suggested, at which we will glance, although I do not think we can decide until Darton has finished his work upon the thermal gradient all over the United States, which is the most pertinent. We may, however, throw out some explanations as incorrect, and we can confirm also the acute observation of Darton that the gradient is lowest over the older rock.

* Any data widely different from this are locally affected and not to be used.

4. Appeal has been made to the cooling effect of Lake Superior on the flanks of the Copper Range.

But draw a section across the point to true scale. Then remember that the bottom of Lake Superior is barely two degrees cooler than the mean temperature of Calumet. Consider that B. O. Peirce* has shown that in a disk six to ten times as broad as high, any change of temperature on the sides, so long as they are between the constant temperatures of the top and bottom, will hardly affect the axial temperatures. We shall be convinced that this is not an efficient explanation.

5. It has been assumed that the very low geothermal gradient was the normal one and the higher due to local chemical action, oxidation of pyrite, etc. But we should expect in such case sharper local irregularities from bed to bed than we have, and if oxidation of pyrite, or gas, or oil, were the causes of high gradient, there is no little of both in the Lower Peninsula of Michigan.

6. The effect of deposition as such would be to depress a given temperature below the surface and lower the gradient, and that of erosion to raise it. But the lower gradients are in regions of erosion rather than of recent or great deposition.

7. I have seriously considered the possibility that the refrigeration of the ice age was still perceptible. If for instance the mean annual temperature during the ice age was 18° F. at Calumet for a very long time, so that the gradient was adjusted to that temperature even down to a mile or more, then for a gradient of 3° in 200 feet the temperature would become 84°. Then if at the end of the ice age, so recently that the surface change of temperature was still unfelt a mile below, the mean annual temperature rose to 40° F., the gradient would be only what it is now,—1° F. in 100 feet. It would be very interesting if we could find the cause of the abnormal gradient here, for we could then compute the time since the ice age. Unfortunately lines of equal geothermal gradient are not, as this theory would require, parallel to the successive lines of the retreating ice front (?).

8. Prof. B. O. Peirce suggests that an inclined band of very conductive rock might lead the heat off along it sideways and thus make very low gradients along it. This was in informal talk with me. For instance, the iron-bearing series might be supposed to underlie the copper-bearing series, and lead off the heat under the bottom of the lake, where it might be dissipated by convection. Unfortunately like so many previous suggestions, the facts we have now to study do not support this suggestion. A cross section to true scale must be used.

* Proc. Am. Acad. of Art and Sciences, Aug. 1898, p. 1.

9. Differences in conductivity may be appealed to to account for differences in gradient. We shall have a low gradient in a good conductor above a poor conductor, and a high gradient in a poor conductor above a good conductor. Water is a poorer conductor than most rocks. Air is vastly poorer. Hence the less porous the rock the better the conductivity, other things being equal.

I trust we may soon have data as to conductivity which will enable us to test the possibilities along this line better than we can at present. It seems likely that the younger rocks are in general less condensed, more porous, and on the whole poorer conductors than the older rocks, especially the crystallines. We might therefore expect that Keweenaw Point and the Archean area of the Upper Peninsula, where heat had been allowed to escape more freely from a very early date through more conductive rocks, might show a lower gradient than an area in which the rocks were not so conductive.

Inasmuch as the gradients are inversely proportional to the conductivity, and Peirce's experiments show that whereas marbles vary in conductivity from 0·005 to 0·007, glass has a conductivity of 0·002 to 0·003, and the difference in conductivity amounts to about a fifth between wet and dry rock, we have here not only a true cause of different gradients, but one that may well be effective, well worthy of farther experimental study.

The next two suggestions may be considered as variations on the same theme, in which, however, the flow of heat is not molecular, but in a larger way, the net effect being the same.

10. Circulating waters are known to be a factor in affecting heat gradients, as the Comstock Lode. In particular at the center of an artesian basin like that of Lower Michigan, the tendency will be for water to work up by joint planes, or any other crevices. If it emerges hot it may naturally produce a steep gradient above it, if it assumes an oblique course; but on the other hand, so far as such waters act in exhausting the stores of heat from below, they would serve to increase the conductivity of the strata as a whole, so that any local increase in gradient must be more than compensated for by a lower gradient elsewhere, and this would be particularly on the elevated margin of the artesian basin where the water was taken, and down which it worked.

The effect of the agency just described is, however, limited by the rapidity of the circulation, and while the structure of Keweenaw Point and some things about the alteration of the rocks favor the idea that downward circulation of water is the cause of the unusual coolness, on the other hand there is very

little water in the deep mines. Darton's researches may throw light on this.

11. The transmission of heat by igneous rocks is different from that by water in that they do not first work down, being slowly heated up. Igneous intrusions will produce, or tend to produce, steeper gradients in rocks overlying them, and igneous outbursts or intrusions will produce lower gradients in the rocks through or over which they work. When, however, the igneous rock has cooled off so as not to be above its environment perceptibly, then the whole series will have temperatures lower than normal, owing to the freer and more rapid loss of heat thereby.

This seems to me worth considering. Both Keweenaw Point and the Vulcan Mine are in regions in which there was intense volcanic activity in the dawn of the earth's history, so long ago that the local volcanic heat may be supposed to be entirely dissipated. But much heat must have been thereby taken from beneath. Hence the rate of increase should be low, as it is. The Lower Peninsula is not known to have any trace of volcanic activity. Hence its thermal gradient should be more nearly normal, as it is. For instance, it is nearly in accord with Hallock's West Virginia* observations. Any gneiss of the original crust should have a higher gradient, according to this theory, than any old cooled off granite massif.

In conclusion, it seems likely that among the three causes (§§ 9 to 11) which seek the cause of low gradients in a more rapid conduction or convection away of the heat of the earth from the interior, the efficient causes of varying geothermal gradients will be found.

* School of Mines Quarterly, xviii, Jan , 1897, p. 148.

Geol. Survey of Michigan, Lansing.

ART. XLVI.—*The Production of the X-Rays by a Battery Current;* by JOHN TROWBRIDGE.

I HAVE lately completed the installation of a plant of twenty thousand storage cells in the Jefferson Physical Laboratory. This gives me over forty thousand volts and a comparatively steady current through a large resistance. One of the most interesting questions in relation to this battery was the possibility or impossibility of producing the X-rays in an efficient manner by means of it. This question has been answered in the affirmative, for the rays are produced with the greatest brilliancy; and it is possible to take photographs of the usual subjects which lend themselves to this method of study. The negatives show great contrasts and there are traces of shadows of the ligaments and the muscles.

The great advantage of this new method of generating the rays is in the possibility of regulating the current and the difference of potential which is necessary to excite the rays; this is not possible by any of the other methods in present use. When the X-ray tube is first connected to the battery terminals no current flows; it is necessary to heat the tube with a Bunsen burner. At a certain critical temperature the tube suddenly lights with a vivid fluorescence and when the anticathode glows with a cherry red the rays are given off with great intensity. I employed a distilled water resistance of approximately four million ohms in direct circuit with the tube. The current, therefore, was not more than three or four milliamperes. It is an interesting spectacle to see the tube glowing in such a brilliant and noiseless fashion.

Since such a large resistance was necessary with the use of forty thousand volts, it seemed possible to produce the rays with fewer cells. Indeed there is no difficulty in exciting them brilliantly with twenty thousand cells; and I see no reason why they cannot be generated by a much smaller number if a suitable tube is obtained.

Since I employed four million ohms in circuit with the X-ray tube, it is evident that there were no electrical oscillations through this circuit. What is needed for the efficient production of the rays is evidently a current in one direction; a current moreover of sufficient strength to raise the anticathode to a cherry red. When the anticathode rises to a white heat the resistance of the tube falls to such degree from the gases which are set free from the terminals and the walls of the tube that the rays are enfeebled. This change of resistance in the tube is a most important phenomenon. It is evi-

dently produced by the outcoming of gases which have been occluded in the metallic terminals and on the glass walls of the tube. Dr. Rollins of Boston has lately described in the Electrical Engineer what seems to me a crucial experiment in this connection. Two Röntgen-ray tubes of the ordinary focus plane pattern were joined together by a cross connection which was at right angle to the axes of the tubes. The arrangement thus constituted a double X-ray tube. This was exhausted to a high degree; the same degree of rarefaction was present in both tubes. One of the tubes was then heated until a difference of potential competent to produce a spark in air of an inch excited the X-rays with great brilliancy; at the same time a difference of potential giving a spark of eight inches could not excite these rays in the other connecting tube; the same degree of vacuum, so to speak, existed in both tubes. The phenomenon of the occlusion of gases seems to be the controlling one in the production of the rays and not the degree of exhaustion. With the steady battery current one can watch this phenomenon to great advantage. When the tube is heated to a certain critical temperature a blue cloud proceeds from one anode and is met by the cathode beam from the cathode. If the strength of the current is then gradually increased by diminishing the resistance in the circuit this blue cloud fills the entire tube and the anticathode grows white-hot and the X-rays cease to appear. When the current is diminished the anticathode sinks to a cherry red, the blue cloud contracts and sinks into the anode and the X-rays come out with great brilliancy. The disappearance of the blue cloud betokens a rise of resistance in the tube; for the glow on the anticathode grows less and less, and presently if the current is not increased the tube is completely extinguished and a reheating is necessary.

A steady battery current with an adjustable liquid resistance is indispensable, I believe, if we wish to study the best conditions for producing the rays. A storage battery of forty thousand volts enables me to try a wide range of voltage and current strength; moreover the radiant point of the rays is less likely to produce ghosts. The tubes glow in a perfectly steady way and the degree of excitation of the rays seems to be under perfect control. The phenomenon of occlusion in an X-ray tube having such an important bearing on the subject of the passage of gases through a rarefied space, I was interested to trace the phenomenon from a pressure one or two millimeters up to the X-ray stage. I used for this purpose an end-on tube of a peculiar construction. One end of the tube was blown out into a thin bulb through which the X-rays could be observed; it was possible to heat this tube strongly so as to

produce a high state of exhaustion; and, moreover, this form of tube was very useful in studying the electrical discharge by a spectroscope. When the tube was exhausted to the stratified discharge stage and was connected to the terminals of the battery, the intensity and form of the stratifications could be changed by increasing or diminishing the strength of the battery current; when this current was increased a blue discharge in the form of a stratification detached itself from the anode and joined the stratifications in the narrow portion of the tube. This process could be repeated until there appeared to be formed a species of stationary wave due apparently to the liberation of gas from the anode meeting a cathode liberation. When the strength of the current is diminished the stratifications disappear in the terminals; more noticeably in the anode than in the cathode. This process can be traced to the X-ray stage. Since there is no electrical oscillation in the circuit; for I had several megohms in circuit, the molecular theory of bombardment together with the phenomenon of occlusion seem to be most important. The end-on tube which I employed was filled with hydrogen obtained by electrolysis from phosphoric acid and distilled water. The gas was passed through caustic potash and phosphoric pentoxide. Hittorf's resistance of iodide of cadmium in amyl alcohol will undoubtedly be better than distilled water in quantitative experiments.

Jefferson Physical Laboratory,
Cambridge, May 15.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Krypton, and its place in the Periodic Series.*—Important results in regard to the new gas, krypton (this Journal, ix, 62) have been recently announced by A. Ladenburg and C. Kruegel. From 850 liters of liquid air they obtained 3 liters of evaporated residue in two Dewar flasks, which afterwards collected in large gasometers, produced 2300 liters of gas. This gas was freed from oxygen by passing over red-hot copper, and the nitrogen was removed from the remaining 120 liters by the method mentioned by Rayleigh and Ramsay for the isolation of argon. The last portions of the nitrogen were oxidized by sparking with surplus oxygen over soda-lye, and the remaining oxygen was absorbed by pyrogallol and soda. Three and a-half liters of dried gas were finally obtained, which were condensed in liquid air to a colorless liquid containing a small number of floating colorless crystals. By fractional evaporation, between the temperature -189° and -147°, several residues were obtained. These proved to be mixtures of argon and krypton, except the last, which was a crystalline body melting at about -147°, and giving a strong krypton spectrum in which the lines D_4 ($586{\cdot}9\mu\mu$) and the green line ($558{\cdot}1\mu\mu$) were brilliant, like hydrogen lines. A careful study of the spectrum led to the conclusion that the substance was nearly pure krypton containing very little argon; the fact of its being a crystalline body also shows that it was probably not a mixture. The density obtained was 58·8, and it is inferred that the new group of elements in air should be placed before Group I in the Periodic Series, as follows: thus He ($=4$) before lithium: Ne ($=20$) before soda: A ($=39$) before potassium; and finally Kr ($=59$) before copper.—*Berlin Acad. Sci.; Chem. News*, lxxxi, 205, May 4, 1900.

2. *A new Sulphide of Arsenic.*—Alexander Scott shows that if a dilute solution of arsenic acid be mixed with a small amount of phosphorus trichloride, and later sulphur dioxide be poured in, after a certain length of time a dark brown precipitate is obtained, which on analysis proves to be a sulphide of arsenic having the composition As_3S. This requires 12·45 per cent of sulphur. Analyses of different samples gave 12·7 to 13·6 per cent, the excess being due to the difficulty of removing every trace of the arsenious sulphide present. The behavior of this substance proved conclusively that it was a definite compound and not a mixture. It is insoluble in solutions of ammonia or colorless ammonium sulphide, but dissolves rapidly in yellow ammonium sulphide, and from the solution, arsenious sulphide is precipitated on the addition of excess of hydrochloric acid. Heat resolves it into realgar, which sublimes, and arsenic, which remains behind. It was at first supposed to be identical with the black sulphur of Berzelius, but this contains only 4·33 per cent of

sulphur and corresponds to the formula $As_{12}S$.—*J. Chem. Soc.*, lxxvii, 651, May, 1900.

3. *Relative rates of Effusion of Argon, Helium, and some other gases.*—Prof. Ramsay and Dr. Collie have found that argon and helium diffuse through a plug into a vacuum with velocities which are higher when compared with a standard gas such as oxygen, than those calculated according to the law of the inverse square root of the density. F. G. DONNAN seeks to ascertain the relative rates of flow of these gases through a small hole in a thin-walled partition. The results obtained were as follows :

(1.) Argon is found to effuse, when compared with oxygen, 3½ per cent faster than as calculated by the law of the inverse square root of the density. This result is independent of any masking effect due to viscosity.

(2.) This result is in qualitative agreement with the adiabatic theory of the efflux of ideal gases, and is, if this may be granted, a confirmation of the high specific-heat ratio of argon.

(3.) When the viscosity effects are eliminated or allowed for, it is found that hydrogen, oxygen and carbon monoxide effuse relatively in the manner predicted by the theory for ideal gases possessing the same, or nearly the same, specific-heat ratio.

(4.) Carbon dioxide, when compared with oxygen, appears to effuse about 1 per cent faster than is calculated from the densities. This result is not in accordance with the adiabatic theory of the efflux of ideal gases.

(5.) The results obtained for helium are not uniform, and are affected by a viscosity correction depending on an empirical formula. They are sufficient, however, to show that the behavior of helium is unlike that of argon—a result which is not foreseen by theory.

(6.) If account be taken of the deviation of ordinary gases from the ideal laws, it is possible to obtain an expression for the efflux which contains a correction term involving the constant K of the Joule-Thomson effect.

(7.) The sign of this correction term shows that a real gas will effuse more rapidly or more slowly than an ideal gas of equal density and specific heat ratio according as K is positive or negative.

(8.) The suggestion is made that possibly the anomalous results obtained with carbon dioxide and helium may be thus explained. The deviations of the observed results from the results calculated for an ideal gas are, in the case of CO_2, in qualitative accordance with the theory proposed. In the case of helium they would be so if that gas possessed a negative K.—*Phil. Mag.*, May, 1900, pp. 423–446. J. T.

4. *Transmission of the radiations of Radium through bodies.*—In the course of an investigation on this subject H. BECQUEREL shows that the absorption of these radiations increases with the distance of the absorbing body from the source of the rays. The absorption is doubtless due to the air path.—*Comptes Rendus*, April 9, 1900, pp. 979–984. J. T.

5. *The new Radio-active Substance, Actinium.*—A. DEBIERNE gives a detailed account of his method of extracting this substance from pitchblende. The new substance produces fluorescence, photographic impressions, ionization of gases.—*Comptes Rendus*, April 2, 1900, pp. 906–908. J. T.

6. *Influence of temperature on the potential-fall in rarefied gases.*—An important paper on this subject by G. C. SCHMIDT gives a detailed account of the methods of work and the apparatus. The Geissler tubes were excited by a storage battery of 1000 cells, the current of which was regulated by a liquid resistance. The following results were obtained :

(1.) Both at constant pressure and with constant gas density, the unstratified light breaks up into stratifications with increasing strength of current, and with higher temperature and strong current the positive light retreats to the anode and finally the discharge becomes dark.

(2.) With increase of temperature of the anode the *Glimmlicht* extends farther and farther with small pressures. The increase of temperature has the same effect as increase of current strength.

(3.) The gradient in the positive light portion of the tube is independent of the cathode fall.

(4.) The gradient in the positive unstratified light with constant gas density, independent of the temperature.

(5.) With heating under constant pressure the gradient diminishes in the positive unstratified light and more slowly than the gas density.

(6.) The cathode fall is, so long as the cathode is still not wholly covered, and is not heated to a white heat, independent of the temperature.

(7.) If the current is increased, after the cathode is already wholly covered, the cathode potential increases, and in proportion with the current strength.

(8.) With increasing current strength the gradient increases with the dark discharge.

(9.) With constant gas density the gradient increases with the temperature at the state of dark discharge.

(10.) With constant pressure the gradient diminishes with the temperature during the dark discharge.

(11.) The gradient diminishes from the anode to the cathode during the dark discharge ; and it is nearly proportional to the distance from the cathode.

(12.) With increasing temperature the whole potential difference between the electrodes diminishes at first slowly and then quickly. It reaches a minimum and then begins to rise.

(13.) The minimum of the potential lies with one and the same tube at so much the lower temperature as the initial difference of potential is lower.

These results have an important bearing on the conditions of excitation of X-ray tubes.—*Ann. der Physik.*, No. 4, 1900, 625–647. J. T.

7. *Les Sucres et leurs principaux Dérivés;* par L. MAQUENNE, Prof. au Museum d' Histoire Naturelle. Pp. 1032. Paris, 1900 (Georges Carré et C. Naud, 3 Rue Racine).—The most important data relating to the classification, constitution and properties of the various sugars are lucidly and very exhaustively presented in this work, which is a real contribution to the literature of the very interesting material it discusses. E. F. S.

8. *A Text-Book of Physical Chemistry;* by Dr. R. A. LEHFELDT, Prof. Physics at the East London Technical College. London, 1900 (Edward Arnold, 32 Bedford street).—Within the compass of three hundred octavo pages the author has presented the facts of his subject in a clear and concise manner; giving to the student what he may usefully read, as well as a store of information which will be heartily welcomed by him if he is at all interested in the "rise of the science as an independent subject." E. F. S.

9. *Lexikon der Kohlenstoff-Verbindungen;* von M. M. RICHTER. Hamburg und Leipzig, 1900 (Verlag von Leopold Voss). —The attempt is made in this volume, which gives the empiric formulas of 67,000 derivatives of carbon, to combine the elements successively in the frequency of their occurrence with carbon, as follows: H, O, N; Cl, Br, I, F; S, P; all others being placed in alphabetical order: A–Z. The arrangement is based primarily on the number of carbon atoms, and then on the number of elements which are present with carbon in the compounds. It is believed that this arrangement will aid very materially the research student and others who are frequently obliged to ascertain quickly and briefly the characteristics of, and to examine the literature relating to, any one carbon derivative. It is certain that the author's comprehensive compilation will be highly appreciated by every chemist. E. F. S.

10. *Jenaer Glas und seine Verwendung in Wissenschaft und Technik;* von Dr. H. HOVESTADT. Pp. 429, 8vo. Jena, 1900 (Verlag von Gustav Fischer).—This considerable volume is a compendium of nearly all that has been written concerning the history, physical and chemical properties, and applications of the famous products of the glass manufactory of Schott & Co. of Jena. Most of its contents has already appeared in various journals and proceedings of learned societies, but a collection of this work into a single volume not only renders it far more convenient of access but it must come to all readers as surprisingly fresh and, above all, surprisingly extensive.

A brief notice of the chapters which deal with questions not at all, or but remotely, connected with optics may conveniently precede a somewhat fuller review of the achievements which the new glasses have rendered possible to the practical optician.

Chapters VII and VIII are devoted to the mechanical and thermal properties of glasses. Their topics range from questions of

density and elasticity to a consideration of the choice of materials for various commercial uses. Chapter IX treats of thermal and elastic alterations which depend upon the recent history of the substance in question; this includes a discussion of the best materials for thermometers, a field in which, as is well known, extraordinary improvement has been attained. Chapter X is given to the chemical behavior of the surfaces of the various types of glass. Chapter XI contains a discussion of the electrical and magneto-optical properties of glasses, including a description of a glass designed for maximum transparency for Röntgen rays.

Turning to the portion which treats more particularly of optical questions, we find in the first chapter an interesting history of the investigations undertaken by Dr. Schott with the direct aim of exhausting all possible means for varying the range and improving the properties of optical glasses. This is followed by chapters reviewing the optical constants of the large number of products thus secured; treating of the history and advantages of Abbe's remarkable invention of the apochromatic microscope; the improvements in the photographic camera objective directly consequent on the enlarged range of materials at the command of the modern optician, and, finally, in Chapter VI, the general discussion of telescopes. In the last a description of the successful application of Porro's ingenious invention of the inverting prism to binoculars by the Zeiss firm is of interest; but undoubtedly the scientific optician will turn with the liveliest interest to that section which treats of the promise of improvement of the astronomical telescope. Here, it must be confessed, disappointment awaits us. It is true that a combination of phosphate crown and borate flint is shown to yield a binary objective of greatly diminished secondary color aberration, but the mechanical and chemical properties of these varieties of glass quite preclude their employment in large lenses. A combination of apparently unexceptionable crown and flint glasses is highly praised by Prof. Wolff as practically free from secondary color as far as the eye can recognize, but as the excessive ratio of focal length of 21/1 is requisite in order to sufficiently reduce the chromatic difference of spherical aberration even for a telescope of about eight inches aperture, the real gain is problematical. Large telescopes of triple combinations are probably still less promising, not only on account of excessive length but also from more numerous reflections, increased absorption, and enhanced cost. It is somewhat remarkable that a binary combination described in this Journal for April, 1889, is not alluded to here, for it is without doubt from all practical standpoints the most efficient double objective yet constructed. This readily admits of the ordinary ratio of length to aperture and has been in continuous use since its invention; but it is true that large objectives of its type are probably impracticable. C. S. H.

II. Geology.

1. *Recent publications of the United States Geological Survey*, Charles D. Walcott, Director. The following volumes have recently been issued by the Survey :

Nineteenth Annual Report. Part II. *Papers chiefly of a Theoretic Nature.* Pp. 712 ; plates 172. This volume includes the following papers : By C. W. Hayes on the physiography of the Chattanooga District; by F. H. King and C. S. Slichter on the movements of ground water (this Journal, p. 157) ; by N. S. Shaler and J. B. Woodworth on the geology of the Richmond Basin, Virginia ; by L. F. Ward on the Cretaceous formation of the Black Hills, as indicated by the fossil plants (see p. 384).

Part III. *Economic Geology.* Pp. 785 ; plates 99. Of the papers here included, that by T. Nelson Dale on the Slate Belt of Eastern New York and Western Vermont has already been noticed (p. 382). Other papers are by J. F. Kemp on the titaniferous iron ores of the Adirondacks ; J. S. Diller on the Coos Bay coal-field, Oregon ; by G. W. Tower, Jr., and G. O. Smith, on the geology of the Tintic District, Utah ; by J. A. Taff, David White and G. H. Girty on the McAlister-Lehigh coal-field, Indian Territory ; also an abstract of Monograph XXXVI by the authors.

Part V. *On the Forest Reserves.* Pp. xv, 400 ; plates 110 ; with Atlas. Mr. Henry Gannett is in charge of this division, and the publication of this volume is a new and admirable feature of the Survey work. Several papers on the forest reserves in different portions of the West are included, in addition to the general discussion by Mr. Gannett, Thus, one on the reserve in the Black Hills, by H. S. Graves ; on that of the Big Horn, by F. E. Town ; of the Bitterroot, by J. B. Leiber ; of Washington, by H. B. Ayres and M. W. Gorman, etc. The volume contains numerous excellent illustrations and is accompanied by an atlas of seventy-five colored plates. As a whole, it forms an exceedingly interesting discussion of a highly important subject.

Twentieth Annual Report. Part I. *Director's Report, including Triangulation and Spirit Leveling.* Pp. 551 ; plates 2. This is noticed on p. 448 of the present number.

Part VI. *Mineral Resources of the United States*, 1898. In two volumes, viz.: Metallic Products, Coal and Coke, and Non-Metallic Products. These volumes give a striking proof of the activity of mineral industry in this country. The Department is in charge of Mr. David T. Day, who, with his assistants and various collaborators, has, as in former years, brought out the material with great fullness and promptness.

Monographs. XXXII. Part II. Geology of the Yellowstone National Park, by Arnold Hague, J. P. Iddings, C. D. Walcott, T. W. Stanton, G. H. Girty, and F. H. Knowlton. Pp. 893 ; plates 121. Noticed on p. 297.

XXXIII. Geology of the Narragansett Basin; by Messrs. Shaler, Woodworth, and Foerste. Pp. xx, 402 ; plates 31.

XXXIV. The Glacial Gravels of Maine and their Associated Deposits; by George H. Stone. Pp. xiii, 499; plates 52.

XXXVI. The Crystal Falls Iron-Bearing District of Michigan, by J. Morgan Clements and Henry L. Smyth; with a Chapter on the Sturgeon River Tongue, by W. S. Bayley, and an Introduction by Charles R. Van Hise. Pp. xxxvi, 512: plates 53. See p. 451.

XXXVII. Fossil Flora of the Lower Coal Measures of Missouri, by David White. Pp. xi, 467; plates 73.

XXXVIII. The Illinois Glacial Lobe, by Frank Leverett. Pp. xxi, 817; plates 24.

[Of the above Monographs, those which have not already been reviewed, will be noticed in following numbers.]

BULLETINS. Number 157. The Gneisses, Gabbro-Schists, and Associated Rocks of Southwestern Minnesota, by C. W. Hall. Pp. 160; plates 27.

Number 158. The Moraines of Southeastern South Dakota and their Attendant Deposits, by James Edward Todd. Pp. 171; plates 27. To be noticed later (also 157).

No. 159. The Geology of Eastern Berkshire County, Massachusetts, by Benjamin K. Emerson. Pp. 139; plates 9. The author recognizes as of Paleozoic Age the following formations, viz.: *Cambrian system*—the Becket gneiss, Cheshire quartzite, and the lower part of Stockbridge limestone; *Silurian system*—the upper part of Stockbridge limestone, Berkshire schist, Hoosac schist, and the Rowe schist.

Number 160. A Dictionary of Altitudes in the United States (Third Edition), by Henry Gannett. Pp. 775. This edition is greatly enlarged, and the adjustment of altitudes is made to record the greater precision reached by recent re-survey of railroad profiles.

Number 161. Earthquakes in California in 1898, by Charles D. Perrine. Pp. 31; plate 1.

Number 162. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for 1898, by Fred Boughton Weeks. Pp. 163. A useful index like the earlier issues of the same series.

2. *Twentieth Annual Report of the United States Geological Survey, 1898–1899;* CHARLES D. WALCOTT, Director. *Part I. Director's Report including Triangulation and Spirit Leveling.* Pp. 551.—This volume containing the Director's report, and a paper on Triangulation and Spirit Leveling, is the first of seven parts which will constitute the twentieth annual report, giving the operations of the Survey for the year ending June 30, 1899. The appropriation for the year amounted to $818,760.02, and the work includes, in addition to the regular geologic work, the study of the forest reserves and explorations in Alaska. During the year a resolution was introduced in Congress providing for a Division of Mines and Mining in the United States Geological Survey. This was referred to the Director, and his report regarding the proposed new Division of Mines and Mining is given in

detail. The general work and organization of the Survey is practically as it was in the previous year. Attention is called to the need for a new building for the Survey and better provisions for preserving the collections, both of the Survey and of the new Division of Mines and Mining. The following distribution of the work in Geology will indicate the extent of the operations of the Survey:

In the New England region, the Shaler party was engaged in studying the geology of Cape Cod and Narragansett Bay districts; the Emerson party was engaged on the Worcester, Marlboro, and Blackstone quadrangles; the Dale party on the Cohoes and Hoosick quadrangles of New York, and the Bennington quadrangle of Vermont; the Wolff party completed the surveys of the Archean rocks on the northeastern portion of the Bennington quadrangle. Professor Wolff studied also the underground workings of the zinc mines at Franklin Furnace. The Williams party continued the study of the Paleozoic rocks of Maine, and certain igneous problems of the same region; the Kemp party continued the survey of the Lake Placid and Ausable quadrangles of New York; the Gilbert party continued surveys in northwestern New York, covering parts of Niagara County.

In the Appalachian region, the parties at work were White, mapping the Pottsville series and Lykens coals, and other areas about Broad Mountain; Campbell, the Oceana (West Virginia) quadrangle; Hayes, at first in Nicaragua and Costa Rica, under detail by the Secretary of the Interior, and after June 3d in the southern Appalachians; Bascom, mapping the crystalline rocks in the Philadelphia district; Keith, in the Cranberry and Cherokee districts of Tennessee and North Carolina; Van Hise, on Mount Guyot quadrangle of Tennessee.

Clarke continued investigations of the Cretaceous and Tertiary in eastern and southern Maryland, and Darton in the District of Columbia, Maryland, and Virginia, in the Atlantic coastal plain region.

The Interior or Mississippi region was explored by Van Hise, in the iron-bearing districts of Lake Superior and Vermilion; by Darton in South Dakota and Nebraska, in the Black Hills region; R. T. Hill in Texas, working on the physical geography problems; Vaughan also in Texas. The Taff party were at work in the Indian Territory, making surveys of the coal field; Emmons in South Dakota, investigating the Black Hills region particularly, where an almost complete representation of sedimentary rocks from the Algonkian to the Tertiary was exploited.

The Rocky Mountain region was explored by the Emmons party who, in Colorado, investigated the underground workings of mines in the vicinity of Rico. Whitman Cross was engaged in the San Juan Mountains of southwestern Colorado; R. C. Hills in the regions of the Elmoro, Spanish Peaks, and Walsenburg quadrangles of Colorado. Weed made geologic investiga-

tions in the Boulder quadrangle, the Helena quadrangle, and a reconnaissance trip to the Big Hole Basin, Gibbonsville, Idaho.

The Hague party continued work on the Yellowstone Park monograph; the Lindgren party on the Hailey, Boise, and Snake River regions of Idaho, and at the request of the Department of Justice, Mr. Lindgren made a detailed examination of Oracle region, in Pinal quadrangle, Arizona.

The Pacific region was explored by the Branner party in the vicinity of Palo Alto, California; and by Becker in the Mother Lode of California, until his work was interrupted by being called to special work in the Philippines. Lawson was engaged on the Mount Diablo quadrangle; Turner on surveys in the Sierra Nevada regions of Yosemite and Mount Dana quadrangles. Diller in the Bohemia mining region of the Blue River and Coos Bay coal-fields, and later in the Port Orford quadrangle. Smith in the Mount Stuart quadrangle, Kittitas County, Washington; Russell made a geologic reconnaissance of the northern Cascade Range, Washington.

Special investigations were continued in the glaciated regions of the United States by the Chamberlin party, and progress made in that field.

Two parties were sent to the Alaska region; one starting from Chilkat Inlet, along the northern side of St. Elias Range to the head of White River. The second party went down the Yukon, proceeding northward toward the Koyukuk River.

Dr. George F. Becker was sent by the War Department to investigate aud report on the mineral resources of the Philippines. To Porto Rico Mr. R. T. Hill was sent for the purpose of investigating the physiographic and geologic features of the island.

Mr. Bailey Willis, as assistant to the Director in Geology, made a flying trip through the Western States, for purposes of conferring with geologists and preparing plans for future geologic work. He visited western Montana, Washington, and California, touching upon the fields under exploration by various parties of the Survey.

The Director, during the field season, visited the Teton Forest Reserve in Wyoming, and made a geologic reconnaissance of the Belt Mountain area east of Helena, Montana. The result of his investigation of the regions south of the Yellowstone was a recommendation to the Government to annex that region as a public park, in order to preserve the game during the winter season, and also because of the grandeur and beauty of the natural scenery in Teton Reserve.

The Division of Paleontology also covered a large field of work: Mr. Girty working on the Carboniferous collections from various localities; Williams on the Devonian and Silurian collections from Maine, Arkansas, and southern Appalachians; Stanton on the Cretaceous of Texas and Kansas; Ward on the fossil plants of the Cretaceous; Knowlton on the Cretaceous plants of Washington and other localities; Dall on the Tertiary faunas of

the Atlantic coast. During the year Professor O. C. Marsh died, and large collections of vertebrate fossils made by him were packed and removed to Washington.

The Division of Chemistry completed 295 analyses during the year.

The Division of Hydrography made detailed examinations in Nicaragua, along the Gila River; in the Great Plains; in the Black Hills region; in Pennsylvania and Maryland; in southwestern Colorado. Investigations pertaining to the work of this Division were carried on in nearly every state of the Union.

The Division of Mineral Resources shows as active work as ever, and reports great increase in the product of the country during the year. The total increase of mineral products, from 1897 to 1898, was nearly sixty-seven millions, and reached the enormous figures of $697,273,907 in 1898. This total is the largest ever recorded for the United States, exceeding by over forty-nine millions the product for 1892.

A concise summary of the development of the Topographic Division is given in the present report. The topography has been carried into all the states and territories, and about 27 per cent of the entire area exclusive of Alaska has been surveyed. The total area surveyed is about 800,000 square miles. The States of Connecticut, Delaware, Massachusetts, New Jersey, and Rhode Island, the District of Columbia and Indian Territory have been completely mapped. A detailed report is given of the amount already surveyed in each district, and the nature of the surveys.

In the Forestry branch of the Survey, the following regions were investigated: The Flathead Reserve, Montana; the Idaho portion of the Bitterroot Reserve; the Mount Rainier Reserve of Washington; the Olympic Reserve of Washington; and Pikes Peak, Plum Creek, and South Platte reserves of Colorado.

In the publication branch of the Survey, the year's work in photography reached a total of nearly 6,000 negatives, 18,000 prints, and over 5,000 slides. The work of the editorial division completed the editing of 16,323 pages of manuscript, and 11,316 printed pages. There were completed and issued also 8 folios, Nos. 44–51, inclusive, and during the year 80 new map sheets were received, which, together with those on hand at the beginning of the year, make a total of 164 sheets. During the year 104,665 volumes, 29,597 geologic folios, and 168,641 topographic maps were sent out, including those distributed under special Congressional enactments.

The library of the Survey has reached a total of 144,370 entries, including books, pamphlets, and maps.

This concise summary, gathered from the Director's report, is sufficient to indicate the very large dimensions of the work carried on by this important Government Bureau. W.

3. *The Crystal Falls Iron-Bearing district of Michigan;* by J. Morgan Clements and H. L. Smyth, with a chapter on the Sturgeon River tongue, by W. S. Bayley, and an Introduction,

by C. R. VAN HISE. Monographs of the U. S. Geol. Survey, vol. XXXVI, pp. 548, 4to with 53 plates and maps.* Washington, 1899.—The report and the accompanying map discussed in this volume cover an area of 1296 sq. miles, including the Crystal Falls, the Amasa, the Felch Mountain or Metropolitan and the Sturgeon River iron ore districts, of which the first two are at present productive, having shipped during 1898 a total of 325,814 tons. The Metropolitan area was formerly also an important ore producer but in recent years the mines have not been worked. The ores are mainly non-Bessemer hematites and limonites.

Geologically the district may be regarded as connecting the Marquette and the Menominee districts. It consists essentially of a broad area of Huronian rocks enclosing two small oval areas of Archean schists and granites, and bordered on the east by an almost continuous stretch of similar rocks. The Felch Mountain and the Sturgeon River areas are two narrow tongues of the Huronian sediments extending eastward from the broad expanse of the Crystal Falls district into the Archean complex.

Structurally the main portion of the district is a N.W.–S.E. set of folds, with a N.E.–S.W. series superimposed upon them. The Felch Mountain and Sturgeon River tongues are two narrow E.-W. synclines.

In structure and lithology the Archean complex possesses no unusual features. Its rocks are biotite-granites and granite-gneisses, banded gneisses, mica-schists and hornblende schists or amphibolites. The origin of the mica-schists and the banded gneisses is not known. The other members of the complex are plainly igneous. They are cut by numerous basic and acid dikes.

Between the Archean and the Huronian is a great basal conglomerate best exposed in the Sturgeon River tongue. Here it occurs with an enormous development. It is a schistose recrystallized arkose containing many large pebbles and small bowlders of granite, gneiss and other Archean rocks. Although the conglomerate is plainly sedimentary, it has suffered such deep-seated metamorphism that specimens of its finer portions can with difficulty be distinguished from specimens of many gneisses.

The Huronian Group is divided, as in the other Lake Superior iron districts, into a lower and an upper division separated by an unconformity. Though definite proof of this unconformity is lacking in the Crystal Falls district, there is little doubt that it exists, since the strata of this district can be traced almost without break into the neighboring Marquette district, where they unquestionably constitute two unconformable series of formations.

In the eastern part of the district the Lower Huronian formations are better represented than in the western portion. In the

* An extract of this monograph appears under this same title as a part of the 19th Annual Report of the U. S. Geological Survey (Pt. III, pp. 1–151). It contains essentially the same discussion as is found in the Monograph with the exception of that relating to the microscopical features of the rocks met with in the district.

Felch Mountain district Smyth distinguishes the following : "The Sturgeon quartzite, with an average thickness of about 450 ft.; the Randville dolomite, with an average thickness of 750 ft.; the Mansfield schist, a mica-schist derived from some clastic rock, with a thickness of about 200 ft., and the Groveland iron formation, composed of two kinds of rock—one consisting of quartz, hematite and magnetite, and the other of an iron-amphibole with quartz and the iron oxides as associates (grünerite-schists). The quartz-iron oxide rocks are composed partly of clastic quartz and partly of crystalline silica. In this respect the ore-bearing member of the formation is intermediate in character between the crystalline ore-bearing member of the Negaunee formation in the Marquette district and the clastic ore-bearing beds at the base of the Ishpeming formation. The iron oxides are thought to have been derived from glauconite or iron carbonate deposited with the original sediments.

In the western portion of the district the Lower Huronian series is represented by the Randville dolomite, the Mansfield slate and a great thickness of volcanic deposits known as the Hemlock formation. The slate formation comprises graywackes, clay slates, phyllites, cherts and iron ores, together with certain other rocks derived from these. Its maximum thickness is 1900 ft. and in it is the only productive Bessemer ore-producing mine in the district.

The Hemlock formation consists almost exclusively of basic and acid volcanic rocks, both lavas and tuffs, and several varieties of crystalline schists derived from them. The thickness estimated from the dip is about 23,000 ft. but this estimate is regarded as excessive. The figures are thought to result from the presence of undiscovered reduplication of beds due to folding. The acid volcanics are rhyolites, the basic ores are basalts. The latter are largely pyroclastic, the former principally devitrified glassy lavas. The basic lavas are characterized almost everywhere by a well-marked ellipsoidal structure. The ellipsoids vary in size from a few inches to 6 or 8 inches in diameter. They are usually ellipsoidal in cross section, and their longer axes are in the supposed direction of flow of the rock in which they occur. They may or may not be amygdaloidal. When amygdaloidal the amygdules are as a rule distributed through the ellipsoids, but on the whole the masses are more scoriaceous on the periphery than near the center. In exceptional cases the amygdules are on the upper sides of the ellipsoids. The matrix between the ellipsoids is often schistose, but at times it appears almost massive. Sometimes it is brecciated. This structure together with much of the spheroidal structure described in basic lavas from other localities, is explained by Clements as due to the fact that the lava was originally of the *aa* form of the Hawaian volcanoes, and that it has since been metamorphosed under the influence of pressure.

All of the lavas have been much altered since their eruption. In the zone of weathering the alteration has consisted largely of

calcification. At lower depths silicification processes predominated.*

The Upper Huronian beds in the western portions of the area consist of graywackes, ferruginous graywackes, micaceous, carbonaceous and ferruginous clay-slates and their crystalline derivatives, and thinly laminated cherty siderite-slates, ferruginous cherts and iron ores. The extensive folding which the series has undergone, coupled with the intrusions of igneous rocks, has made crystalline schists from some of the slates and graywackes. Interlaminated with these schists are also some perfectly crystalline hornblende-gneisses, that are supposed to have resulted from the metamorphism of intrusive sheets or interbedded flows of basic igneous rocks. Because of the scarcity of exposures the authors were not able to separate the Upper Huronian beds into formations.

The ores in the Upper Huronian are non-Bessemer. They are associated with cherts, and together with these rocks form lenticular bodies lying in the troughs of synclinal folds with impervious slate bottoms.

Cutting through the Huronian sediments are various acid and basic intrusives which in the main are massive and possess the granular texture. Since they nowhere seem to be involved in the folding of the district it is concluded that they were intruded after the folding took place, and since many of them are very similar petrographically to the lavas of the Keweenawan series further north, they are correlated with the latter. The time of folding of the district is therefore placed at the beginning of Keweenawan time.

Lithologically the intrusives are classed as biotite-granites, muscovite-biotite granites, metadolerites, metabasalts and picrite porphyries or porphyritic limburgites. The dolerites have metamorphosed the Mansfield slates with which they are in contact, producing from them spilosites, desmisites and adinoles.†

Near the town of Crystal Falls there is an extremely interesting series of intrusions ranging from acid granites, tonalites and quartz-mica diorites through diorites of intermediate acidity to basic hornblende-gabbros, gabbros, norites and various peridotites. It was not possible to determine which of these rocks most nearly resembles in composition the original magma of which the various types are differentiation products. It is known, however, that the hornblende-gabbro first reached its present position, and that in general the forces of differentiation were toward increasing acidity and increasing basicity.

* Since the publication of this monograph the results of a detailed examination of the Menominee district, which is more closely related to the Crystal Falls district than is the Marquette area, seems to show that the Mansfield slate, the Groveland formation and the Hemlock formation are all members of the Upper Huronian and that the Bessemer Mansfield ore is the equivalent of the Upper Huronian Bessemer ores of the Menominee range. The division between the Lower and Upper Huronian would, therefore, seem to be between the Randville dolomite and the Mansfield slate.

† Cf. this Journal, IV, vii, 81, 1899.

In his general introduction to the volume, Van Hise calls attention to the fact that while the Hemlock volcanics were being erupted in one portion of the district the Mansfield slates and the Groveland formation were being laid down in other portions, and that consequently the former is equivalent in part of the district to the last two-named formations in other parts. The History of the Crystal Falls district closely parallelizes that of the Marquette district, though the number of distinct formations recognized in it is smaller.

In Chapter ii of Part II of the volume, Smyth presents an interesting discussion of the use of magnetic observations in mapping the distribution of magnetic formations and working out their structure. The chapter is an abstract of a paper presented at the Colorado meeting of the American Institute of Mining Engineers in September, 1896. It contains many points of great value to field geologists, especially to those who are engaged in the study of iron-ore regions, and it is extremely interesting from a theoretical point of view.

It is unfortunate that the authors were so handicapped in their work by the lack of exposures, since some of their conclusions, to one unfamiliar with the region, appear to rest on insufficient data. But when we remember that they had the results of the work in the Penokee and the Marquette districts to guide them in their investigations, it would seem that their conclusions must in the main be correct. They have at least shown without any possibility of question that in the Crystal Falls district as in the other Lake Superior iron districts, the ores occur in Huronian beds which are unconformably above an older series of crystalline schists, and that the ores were deposited in pitching troughs as concentrates. Glauconite or some iron carbonate was the original source of the iron and descending waters were the agents of decomposition, transportation and precipitation.

The volume is well illustrated with 14 maps and plates of geological sections in the body of the book, two maps in a pocket, 37 other plates, of which 27 are microphotographs and 24 figures in the text.

4. *Preliminary Report on the Cape Nome Gold region in Alaska;* by F. C. Schrader and A. H. Brooks. Pp. 56 with maps and illustrations. Washington, 1900 (U. S. Geological Survey).—The prompt way in which the United States Geological Survey comes forward with scientific information in regard to subjects of immediate interest to the public, has rarely been better shown than by this Report on the Cape Nome Gold Region, which is based upon observations made by Messrs. Schrader and Brooks, in October, 1899. It states that the bed-rock of the Nome district consists of more or less altered limestones, mica-schists, and gneisses. The rocks are closely folded and have an east-west strike. Mineralized quartz and calcite are common. The gravels are classified as gulch, terrace, and tundra gravels, those of the beach being closely related to the latter. The

presence of these terraces indicates that the entire region has been slowly elevated. The important gold deposits thus far exploited are the gulch and beach placers. Gold is also known to occur in the bars of the larger rivers and in the tundra. Probably the higher benches and terraces are also worthy of investigation by the prospectors.

Although the occurrence of gold in sea-shore sands is not peculiar to this region, still the richness of the Cape Nome beaches is very remarkable; $3,000,000 is given as the probable gold production for the region for 1899.

The Report is accompanied by a series of maps and half-tone representations of the scenery of the coast, and closes with suggestions to those interested in regard to the special conditions involved in mining in this region.

5. *Preliminary Report on the Klondike Gold Fields, Yukon District, Canada;* by R. G. McConnell, 2 plates, 2 figures, map, pp. 5–44, 1900. Geological Survey of Canada, No. 687.—This report was prepared for the annual summary report of Geological Survey Department, but is printed, separately issued, before the latter. It may be regarded as the first result of a systematic and moderately detailed scientific examination of the district.

The Canadian Survey has also issued the following maps of Cape Breton, Nova Scotia: 652, Cape Dauphin Sheet; 653, Sydney Sheet; 654, Glace Bay Sheet.

Also, No. 685, *Descriptive Note on the Sydney Coal Field, Cape Breton, Nova Scotia*, by Hugh Fletcher, pp. 3–16, 1900.

6. *Twenty-fourth (and final) Annual Report of the Geological and Natural History Survey of Minnesota for the years 1895–1898;* by N. H. Winchell, State Geologist, pp. vii–xxviii, 1–284, 1899.—The volume consists chiefly of notes on the rock specimens collected in the years 1896–1898, inclusive, a record of field work for years 1892–98, and a general index of the annual reports I–XXIV, 1872–1899.

7. *George Huntington Williams Memorial Lectures on the Principles of Geology.*—It will be remembered that at the Johns Hopkins University a course of lectures, dealing with the principles of geology, is provided from time to time by the generosity of Mrs. George Huntington Williams, in memory of her husband, the late well known geologist and petrographer, who died in 1894. This lectureship was inaugurated in 1897 with a course by Sir Archibald Geikie, who delivered in April of that year six lectures on *The Founders of Geology.*

The second course has recently been given by W. C. Brögger, the eminent geologist, professor in the University of Christiania, Norway. He delivered two lectures on *The Principles of a Genetic Classification of the Igneous Rocks*, followed by five lectures on *The Late Geological History of Scandinavia, as shown by changes of level and climate in southern Norway since the close of the Glacial epoch.*

These lectures were given between Wednesday, April 25, and Thursday, May 3. They were delivered in English and before good audiences ; a number of visiting geologists from Washington and elsewhere being present. In his first two lectures the speaker said essentially as follows, after referring to the particular circumstances under which the course of lectures was given :

There has been evolution in classification, from the early pre-Linnean and Linnean systems of botany and zoology to the natural systems of the present day. Classification of petrography should (or will) follow the same course. In the case of rocks there is a constant effort to reach a natural system, i. e., a genetic one. The aim of classification is to group objects by their essential characters. What are then the essential characters in rocks? Primarily they are geological bodies, and therefore their classification should be based on geological observations and geological relationships. Rocks produced by the same processes should be grouped together. The name diorite is essentially genetic because the idea is implied that it is igneous, next because the place of consolidation is indicated, and finally because it is understood that it must have originated primarily from the magma.

The present system is founded largely on accidental characters; thus, for example, minettes and leucite-basanites are chemically identical, but are separated and put in different families. The present system is not a natural but an artificial one, comparable to the Linnean system of botany.

Petrographical classification began in 1811 with Haüy, and was based on mineral composition. This has predominated ever since and the consequence is that like rocks are separated and unlike put together, so for example the granites and granitites, augite-andesites and hornblende-andesites are separated, while nephelinite embraces many different rocks. A purely mineral basis is quite insufficient. In 1875 Lossing, in a memoir on the Bodegang in the Hartz, established the connection between quartz-porphyry and granite. This was of the highest importance. He showed that both were only structural modifications of the same magma, and therefore the structure was a function of the conditions of the genesis of the rock. Structure has since then been maintained by Rosenbusch and others as the main basis of classification. Thus Rosenbusch's three main groups (abyssal, dike and effusive rocks) are well founded types, characterized by special structures. It is urged by opponents that this is purely hypothetical, but this is based on a misapprehension, for Rosenbusch's classification is not founded on hypothesis, but on geological observation of facts, which have been made once for all. Exact definitions are of course very hard to give, but this is always so in nature, where there are no sharp limits. While the same chemically, granite, quartz-porphyry and liparite are different structurally and genetically and a system of classification should express these differences.

Structure is very sensitive, and gives the history of a rock, either alone or with the help of geological observations. (The lecturer then spoke of different kinds of metamorphism, and showed that structure could distinguish between the different kinds.) The essential criterion of the various metamorphic rocks of granitic character is genesis, not structure or mineral composition. There is a distinction between the cataclastic and protoclastic structures, the latter being a structure like cataclastic, but produced during solidification, and hence is primary. These should be distinguished in a system of classification. Structure only indicates that the rock has been pressed: geological observation should do more, and indicate whether during or after solidification.

Classification must go back to geological observations as a fundamental criterion.

In regard to the porphyritic structure it is believed that this indicates interrupted movement in the magma.

The finer distinctions and splitting up of "sack (catch-all) names" will separate types now together. That it is possible to found a system of classification on abyssal, hypabyssal and effusive rocks is proved by Rosenbusch. For many years petrography was a science of specimens and thin sections, bnt it should be more than this and should be living. Of all criteria geological observation is first, since it gives the history and changes a dead science to a living one, showing evolution of one rock from another.

In his second lecture the subject was continued essentially as follows: It is well known that rocks of different chemical and mineral composition occur together, so that they are genetically related. It is only within the last few years, from elaborate studies made by different petrographers, that an explanation of differentiation has been brought out. As the result of these studies the various kinds of differentiated masses may be classified as follows:

1. Composite dikes.
2. Complementary dikes.
3. Constitutional (e. g., marginal) facies.
4. Connected occurrences (e. g., leucocratic with melanocratic rocks).
5. Dike associations (*Ganggefolge*).
6. Petrographical provinces.
7. Original earth magma, from which others are derived. (The latter is probable, but the arguments in favor of it cannot be discussed here.)

Classification should be based in the first instance on chemical composition. Geological observations prove the essential connection of the chemical composition of igneous rocks. The essential features of classes 1–6 are geological and independent of theory. On these facts a system of classification should be based.

As geology cannot reach very far down into the earth, stocks and laccoliths (in a broad sense any large, deeply consolidated mass of magma) must furnish our types. All rocks which can be referred to the same magma must belong to the same family.

We have first to distinguish abyssal rocks, then marginal facies, then hypabyssal dikes and sheets (including diaschistic and aschistic,* in the former complementary types, in the latter main rock and salband), lastly flow rocks, palæotypic and cænotypic, diaschistic and aschistic.

Families with the same predominating metallic oxide should form one series. Thus there would be as the main families the *potash*, the *soda*, the *lime* and the *magnesia* series; the alumina and iron rocks are doubtful because they are not known to occur as stocks or laccoliths. Further there are transition series, the *potash-soda* and the *alkali-lime* rocks. There are therefore six main rock families. As regards *silica* we should distinguish hyperacid, acid, intermediate, basic and ultrabasic. Thus as examples we would have

Soda Family	Hyperacid.	Soda-granite.	Akerite.
	Acid.	Soda-quartz-syenite.	Nordmarkite.
	Intermediate	Nepheline-syenite.	Foyaite.
		Soda-syenite.	Laurvikite.
	Basic.	Absent.	
Alkali-lime Family	Hyperacid.	Adamellite.	
	Acid.	Banatite.	
	Intermediate.	Monzonite.	
	Basic.	Essexite.	
Lime Family	Hyperacid.	Tonalite.	
	Acid.	Quartz-diorite.	
	Intermediate.	Diorite.	
	Basic.	Gabbro and Anorthosite.	

The families are to be defined by the chemical composition of the main rock types, limits of course to be considered. The connection of aschistic types with abyssal rocks is well known, obvious, and not denied by any petrographer. All such aschistic structure types should be referred to the related abyssal magma. This is generally believed and done.

Diaschistic dikes should also be referred to abyssal magmas (rocks) from which they are derived. This will be the main difficulty with most petrographers. It is proved by geological observation that they are consanguineous; South Norway furnishes excellent examples which have been studied and described. The relationships are very clear for the hyperacid, acid and basic families; only the intermediate ones are difficult to decipher, such as those of the nepheline-syenites.

The differentiated (e. g. dike) types can have quite different compositions (chemical and mineralogical) from the main type. This is quite analogous with the classifications brought out by

* For the explanation of these terms conf. Brögger Grorudit-Tinguait Serie 1894, p. 155.

zoologists and botanists, as for example certain parasitic and other forms of animal life are grouped with particular families, though they differ in some essential respects, because it has been shown that phylogenetically they are related.

The objection can be raised that these ideas are founded on hypotheses. It is thought that our present knowledge is insufficient, but it should be pointed out that these are problems to be solved in the future, and that petrography is the same now as botany and zoology in the time of the Linnean system.

The most important objection is that of Iddings, that different *genetic* rock families must include rocks of essentially the same character; thus camptonites may occur with essexites or nepheline-syenites. Classification must recognize this and Iddings is right in so far that rocks like the foregoing must have the same main name, thus essextite-camptonite and foyaite-camptonite. But even here the essexite-camptonite will differ from a foyaite-camptonite enough so that they may be distinguished.

But rocks must not be studied as mere rock specimens. Description and classification are two different things, and the separation of petrology and petrography should be strongly objected to.

But every artificial system has had to give way in time to a natural one, and as in botany petrographers could have a "key" for identification, such as botanical text-books have. But the two are essentially and in reality different. Rocks should be studied as they occur in nature.

Every separate rock of given chemical and mineralogical composition should have its own name, but this is no reason for giving up the attempt to determine and express genetic relationships.

The definition and description of the different rock species is not here attempted. A very great number of names is necessary and they will increase. They are not to be stopped by any congress or popes of geology. We are only at the beginning. But even if names should be ten times as numerous as they now are, it does not matter, neither can it be helped since they are necessary. Botanists and zoologists have hundreds of thousands of names as arbitrary as those of petrography, while petrographers have only a few hundreds to consider. If necessary we must make petrographical dictionaries, which must keep pace with the names.

Names now considered as type names will be found to be "sack names." Species will be split up. This will grow out of the study of the relations of consanguinity, and most detailed descriptions are necessary to know the relationships. The many new names show that petrography is on the way from a pre-Linnean and Linnean system to a more advanced and natural one.

The fear of the deluge of new names is one of the children's diseases which we shall soon escape. Michel-Lévy's dream of a simple system of classification will never be realized. The detailed study of single occurrences is the real basis of petrographical classification and this will necessitate new names.

H. S. WASHINGTON.

III. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The forty-ninth annual meeting of the American Association will be held at Columbia University, Morningside Heights, New York City, June 23 to 30, 1900. The Association headquarters will be located in Room 309, Schermerhorn Hall, Columbia University, where the register will be opened at 2 P. M. of Thursday, June 21. The hotel headquarters of the Council of the Association will be at the Majestic, Central Park and 72d street. The opening session of the Association will be held at 11 o'clock A. M. on Monday, June 25th, in the Gymnasium; at this time the retiring President, Mr. G. K. Gilbert of Washington, will introduce the President-elect, Professor R. S. Woodward of New York City. The address by Mr. Gilbert will be delivered Tuesday evening in the lecture room of the American Museum of Natural History.

A circular giving the preliminary announcements in regard to the conditions regulating the admission of members and the presentation of papers; also as to the times and places of meeting of the Association and of the affiliated societies; hotel accommodations, railroad rates, excursions, etc., has been recently issued and copies may be obtained from Mr. L. O. Howard, General Secretary, Cosmos Club, Washington. For further information respecting local arrangements, transportation, hotel and boarding-house accommodations, application may be made to the Local Secretary, Professor J. McK. Cattell, Columbia University, New York City.

2. *Report on the Petrified Forests of Arizona;* by Lester F. Ward, Department of the Interior, Washington, 1900.—The present report was made in compliance with instructions from the Director of the United States Geological Survey especially with reference to the proposition to set aside the region embracing the Petrified Forests as a national park.

The Petrified Forest, or Chalcedony Park, or Lithodendron (stone tree) Valley, as it has been variously called, is situated in Apache County, Arizona, between the Little Colorado and the Rio Puerco, fifteen miles east of their junction, seventeen miles east of Holbrook, and six miles south of Adamana station on the Santa Fe Pacific Railroad. The area in which the fossil coniferous trunks are particularly abundant is about eight miles square, though at other points in the same Triassic terrane in Arizona, New Mexico and Utah, much silicified wood occurs.

As the result of his visit during the preceding summer, Professor Ward fully confirms the various descriptions of the extent and wonderful character of the gigantic silicified Arizona forest. Its interest, moreover, is much enhanced by the fact that it is very old, probably of Triassic age. The great fossil forests of California and the Yellowstone Park are Tertiary and compared with those of Arizona of comparatively recent date; the latter

being the only examples of such ancient forests in this country. The destruction of this natural wonder, due to the piecemeal inroads of idle curio hunters and other more persistent and determined despoilers, is becoming more apparent with each succeeding year, so that there is now considerable local sentiment in Arizona in favor of withdrawing the area in which the chief forest is situated from entry and making it a national reservation. Professor Ward strongly favors doing this in a simple and inexpensive manner which he outlines. It is much to be hoped that Professor Ward's recommendation may be carried out.

3. *University of Tennessee Record.* Number XI, pp. 213–263. October, 1899.—This number, published by the University of Tennessee, contains a record of engineering work done in 1899. The leading article, by J. R. McCall, is on electric transmission of power in shops; another article by W. W. Fulton describes an electric-recording river gauge.

4. *Neues Jahrbuch für Mineralogie, Geologie und Palæontologie.*—In connection with the long-honored "Neues Jahrbuch" a *Central-blatt für Mineralogie, Geologie und Palæontologie* is to be issued, which shall contain short original papers, book notices, authors' extracts of papers, reports of Scientific societies, etc. It will appear twice each month and will be sent free to subscribers to the Jahrbuch: to others at a cost of 12 marks. All workers in these departments will welcome this new publication, which while not interfering with the sphere of the Jahrbuch itself (e. g. in the direction of *full* abstracts), will make possible a much more prompt and complete publication of matters of immediate interest.

5. *McGill University.*—At the annual convocation of McGill University, held in Montreal on April 30th, the degree of LL.D., *honoris causa* was conferred upon George F. Barker, Professor of Physics in the University of Pennsylvania; Alfred T. Mahan, Captain U. S. Navy, and J. F. Whiteaves, F.R.S.C., of the Geological Survey of Canada.

6. *K. K. Geologische Reichsanstalt.*—A Jubilee meeting to commemorate the founding of the Geologische Reichsanstalt, in 1849, will be held at Vienna on the ninth of June.

OBITUARY.

THE DUKE OF ARGYLL, alike eminent for his philosophical writings on scientific subjects, and for his eminent services in public life—not the least in furthering the interests of science—died on April 24th, at the age of seventy-seven years.

Professor A. MILNE-EDWARDS, Director of the Museum of Natural History at Paris and one of the ablest of the recent zoologists, died on April 21st, at the age of sixty-four years.

JOSEPH BERTRAND, the able writer on Mathematics and Mathematical Physics, died at Paris, on April 3d, at the age of seventy-seven.

INDEX TO VOLUME IX.*

* This Index contains the general heads, BOTANY, CHEMISTRY (incl. chem. physics), GEOLOGY, MINERALS, OBITUARY, ROCKS, and under each the titles of Articles referring thereto are mentioned.

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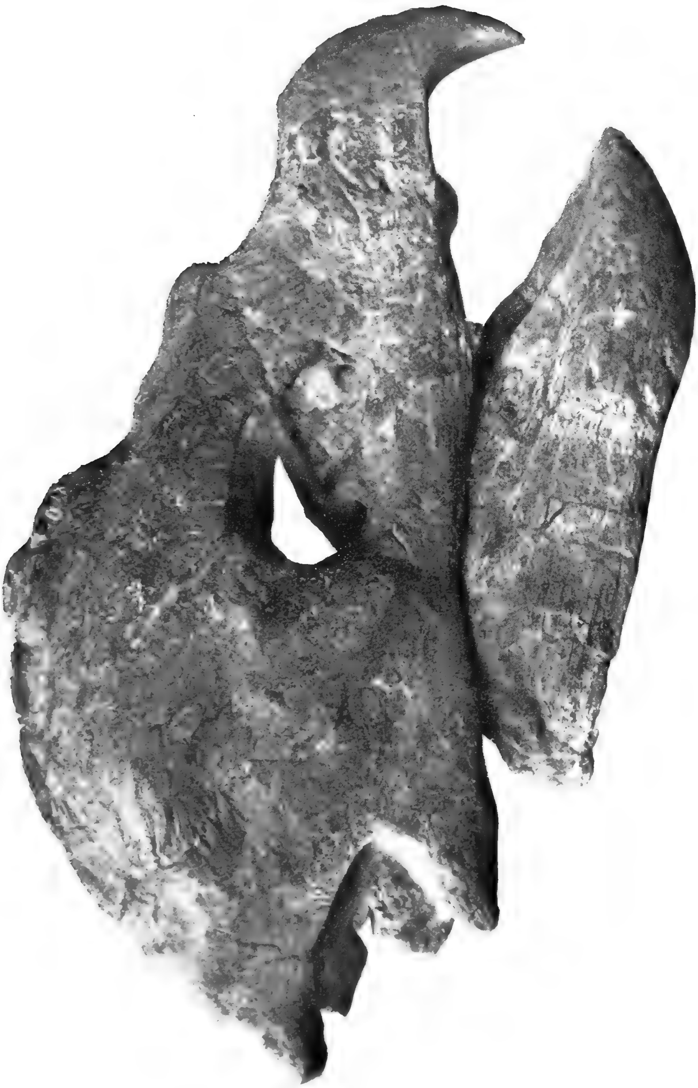
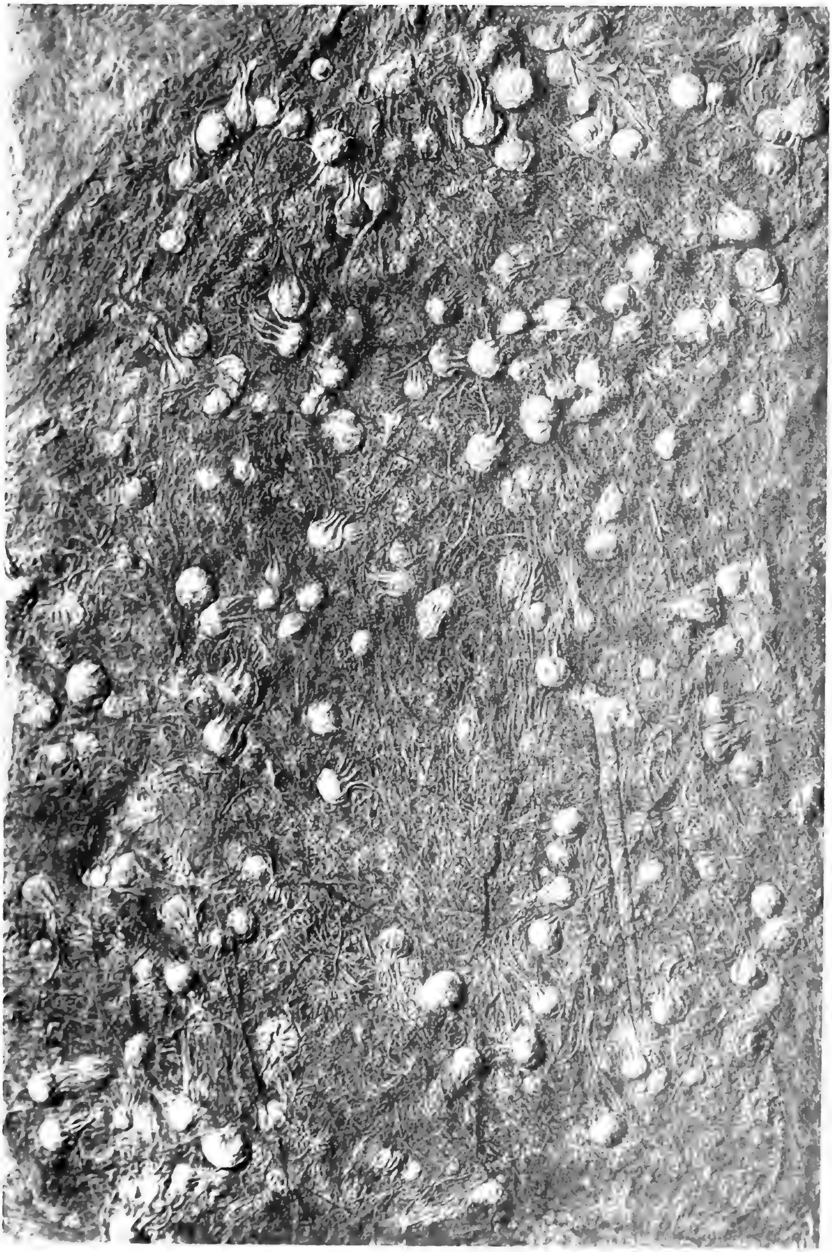
MAP OF
SOUTHERN PATAGONIA
FROM A MAP OF
SOUTHERN ARGENTINA
BY DR. FRANCISCO P. MORENO,
with additions and corrections by
J. B. HATCHER
Scale of Miles
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
GULF OF ST. GEORGE
PORT DESIRE
PORT S. JULIAN
PORT STA. CRUZ
PORT GALLEGOS
GULF OF PENAS
L. BUENOS AIRES
R. DESIRE
R. CHICO
L. SAN MARTIN
L. VIEDMA
R. SANTA CRUZ
L. ARGENTINO
R. SHEHUEN
R. Gallegos
St. OF MAGELLAN
TIERRA DEL FUEGO
SAN SEBASTIAN BAY
USELESS BAY
BRUNSWICK PENINA.
KING WILLIAM LAND
HOSTE I.
NAVARIN I.
STATEN I.
CAPE HORN
QUEEN ADELAIDE ARCHIPELAGO
DESOLATION I.
HANOVER I.
WELLINGTON I.
CAMPANA I.
TRINIDAD CHAN.
MADRE I.
Beagle Chan.
Mt. Darwin
Mt. Aymond
L. Blanca



Skull of Archelon Ischyros Wieland. $\times \frac{1}{5}$.



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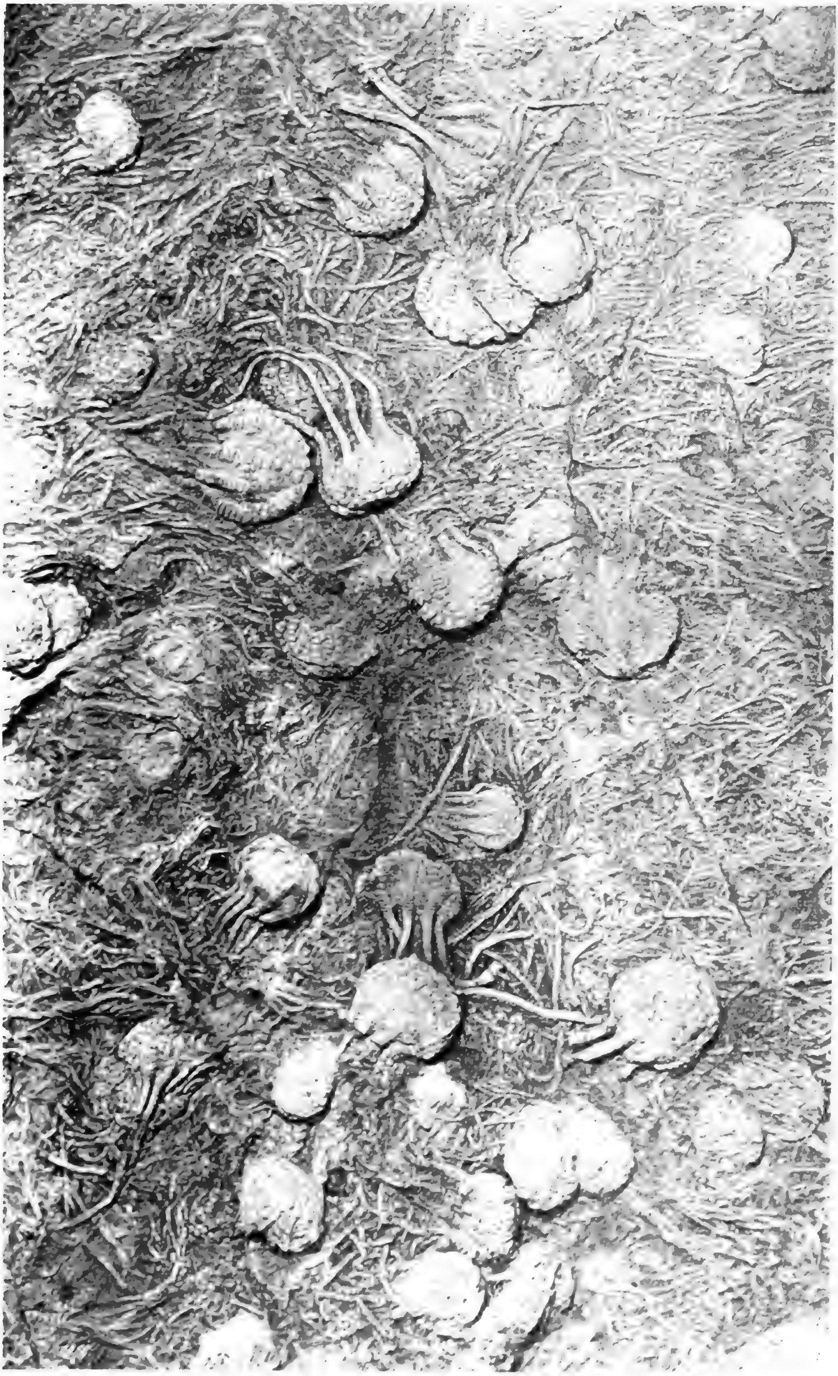

Uintacrinus.

Siliceous Calcites from the Bad Lands. South Dakota, $\times \frac{1}{3}$.

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